(Extreme) Dynamics of (very) hot plasmas

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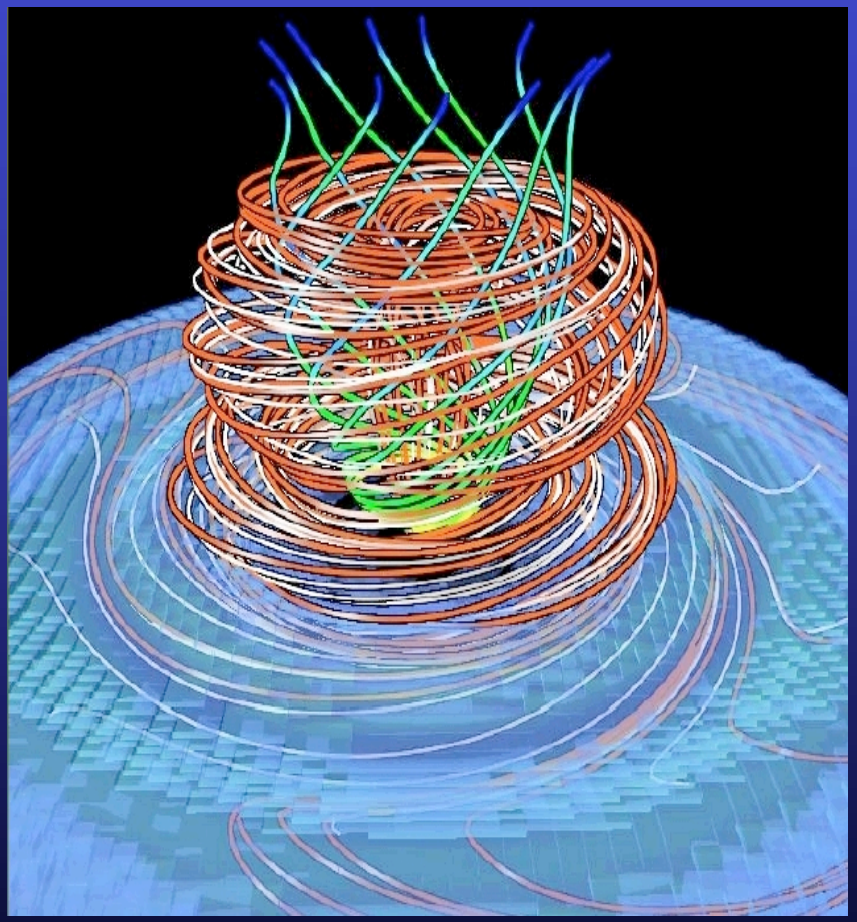


Dynamics (_v) not (only) kinematics (v)

Topic is accretion and ejection in/from AGNs (Sey & QSOs)

(A new, interesting science case for X-ray absorption spectroscopy!?

Collaborators: M. Dadina, , G. Ponti, G. Malaguti, G. Palumbo, P. Grandi

Thanks for inputs from: all italian members of XAWG + G. Matt, J. Kaastra, F. Nicastro, M. Elvis

Outline - Framework

1) Accretion flows <---> Inflows

1a) Fast variations of FeK *emission* with red and blue shifts

⇒ [see Fabian & Reynolds's talks]

1b) New cases for transient, redshifted *absorption* lines

2) Ejection flows <---> Outflows

2a) Warm absorbers

2b) New cases for blueshifted absorption lines (massive outflows)

3) Simulations:

XMM-Newton (long exp.), ASTROE-II, XEUS

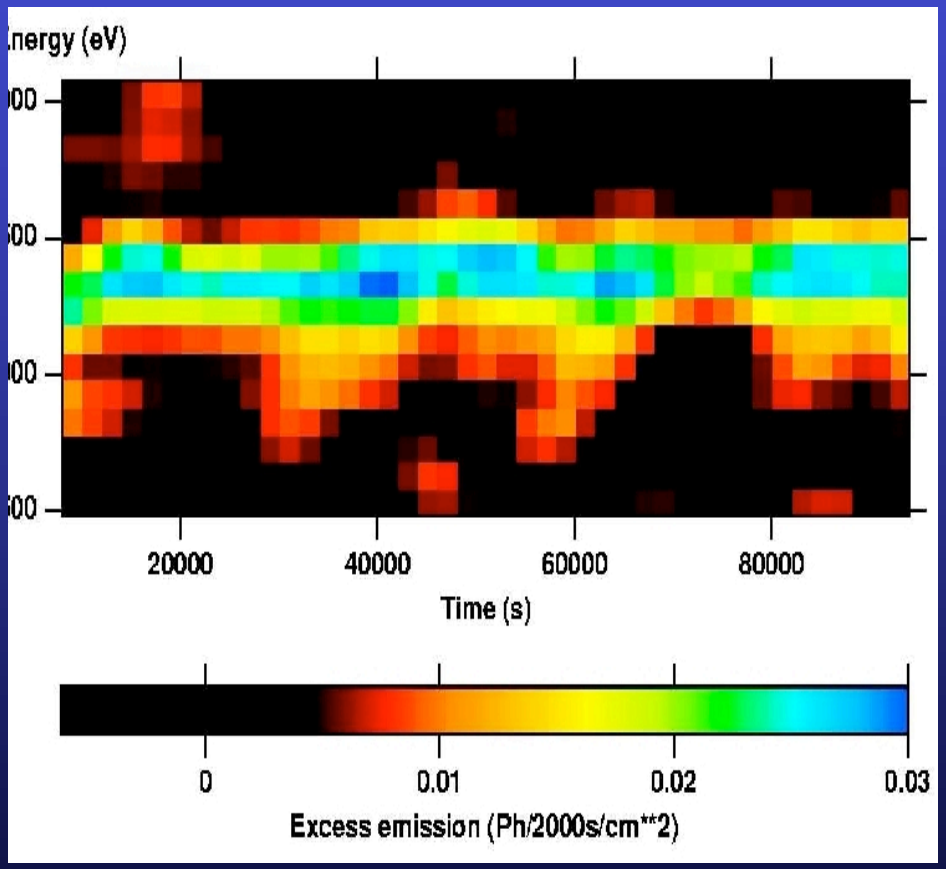
4) Cosmological importance [see Hasinger, Brandt, Mushotzky & Arnaud's talks]

Accretion/inflows: FeK *emission* lines (i/i)

Complex & fast time variations!!

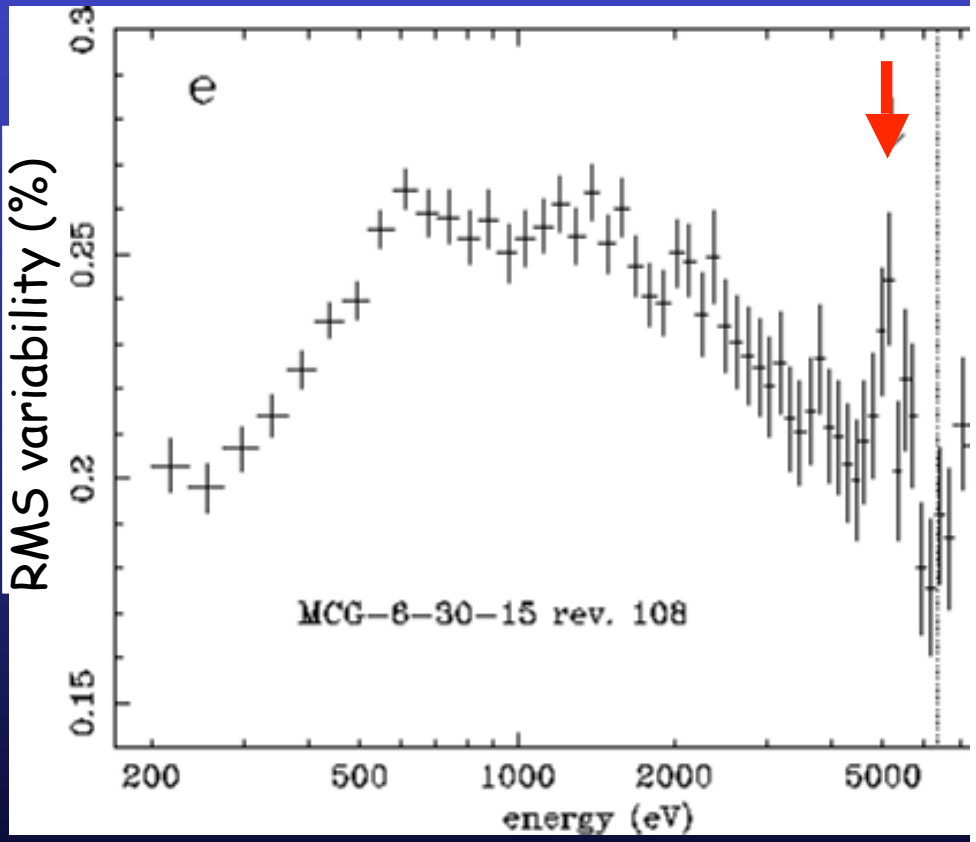
⇒ Probe innermost regions of accretion disk

XMM - NGC3516



Iwasawa et al., 2004
(astro-ph/0409293)

XMM - MCG6-30-15

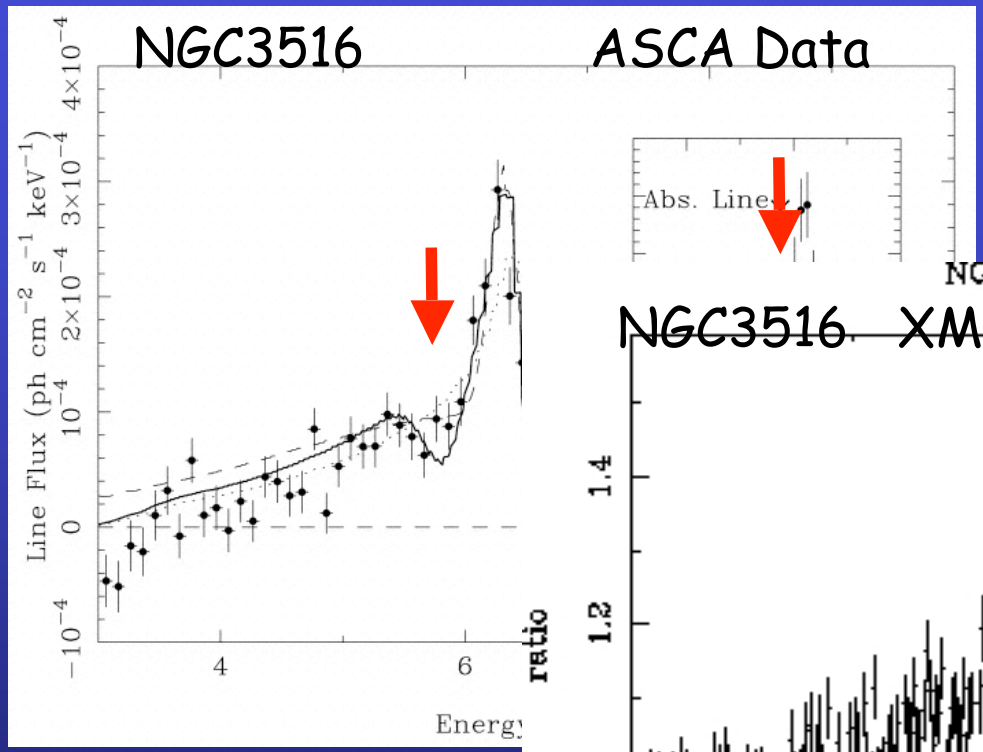


Ponti et al., 2004, A&A

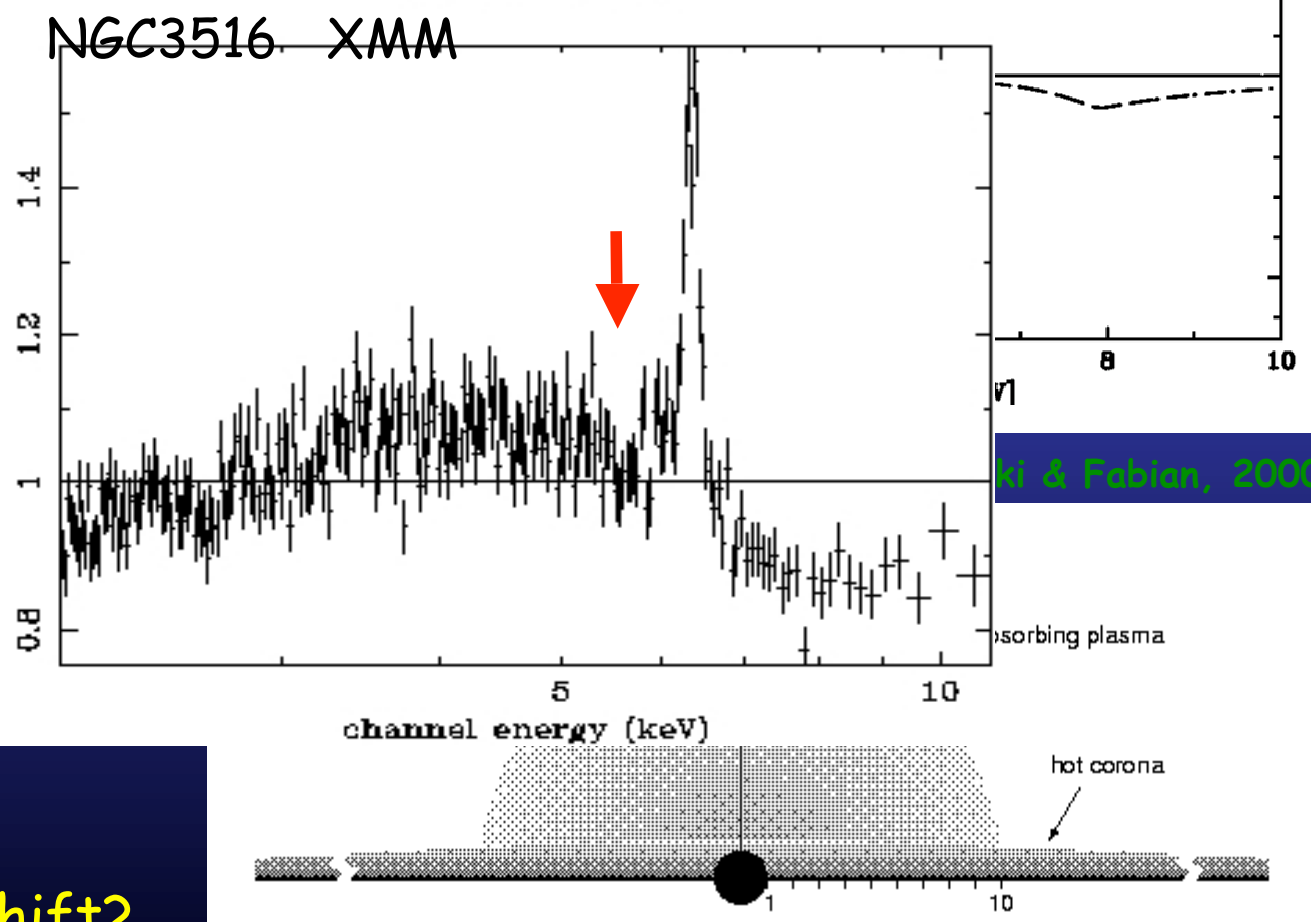
(see Fabian & Reynolds's talks)

Accretion/inflows: FeK resonant *absorption* lines (i/v)

Narrow/broad(?) redshifted absorption lines



(Nandra et al., 1999)

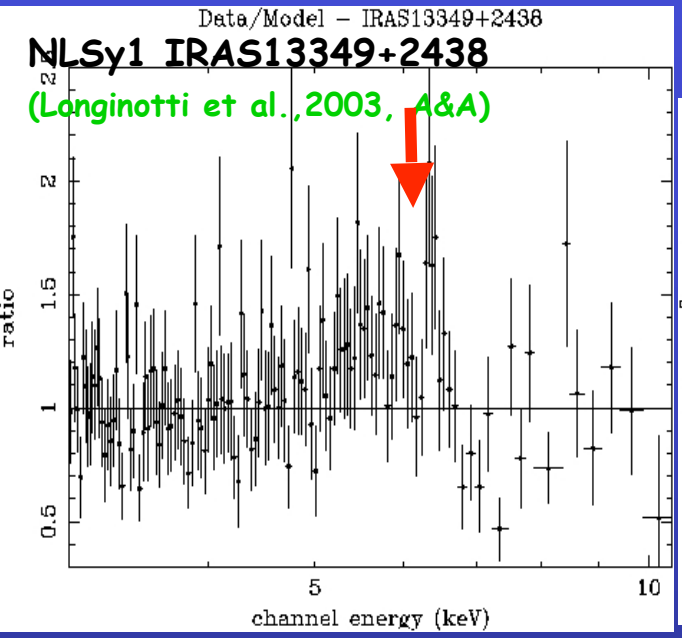


ki & Fabian, 2000

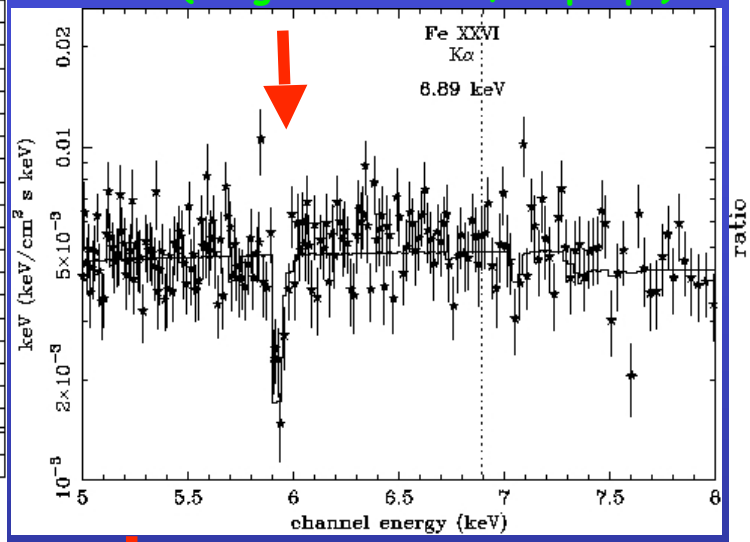
sorbing plasma

Redshift ⇒
Inflow (v~0.2c)?
Gravitational redshift?

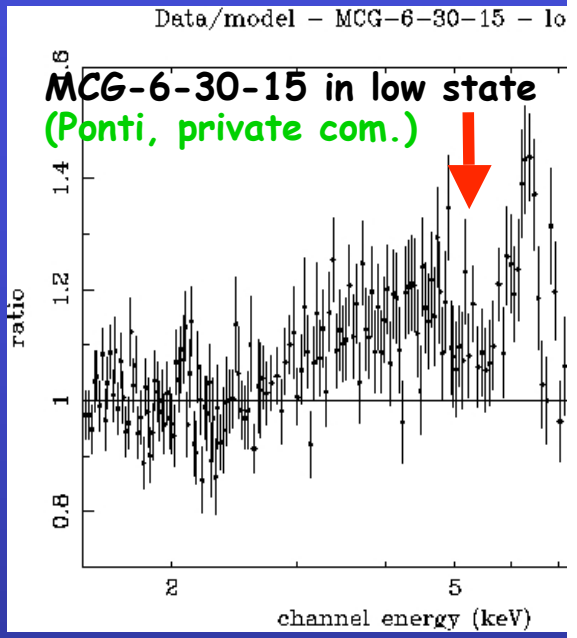
Accretion/inflows: FeK resonant *absorption* lines (ii/v)



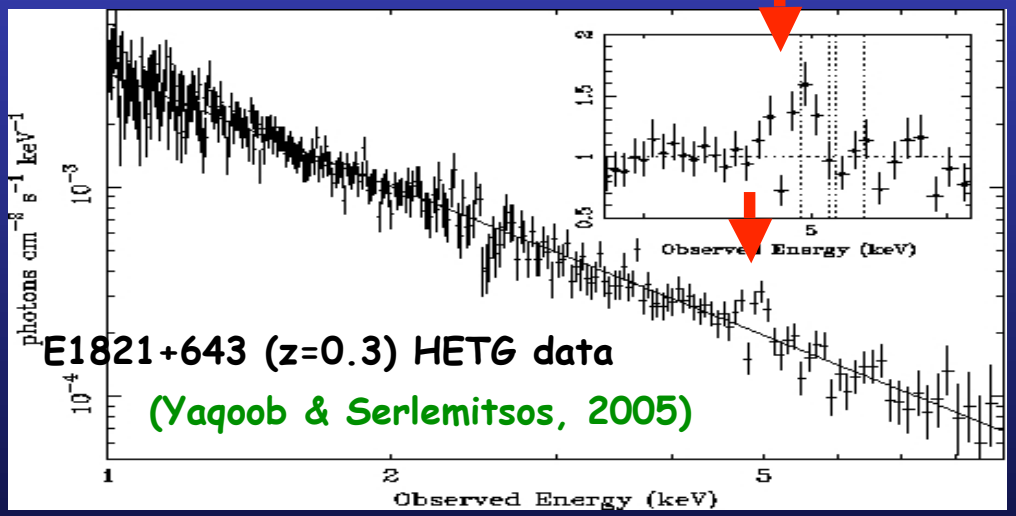
NLSy1 IRAS13349+2438
(Longinotti et al.,2003, A&A)



Mrk335 (Longinotti et al., in prep.)

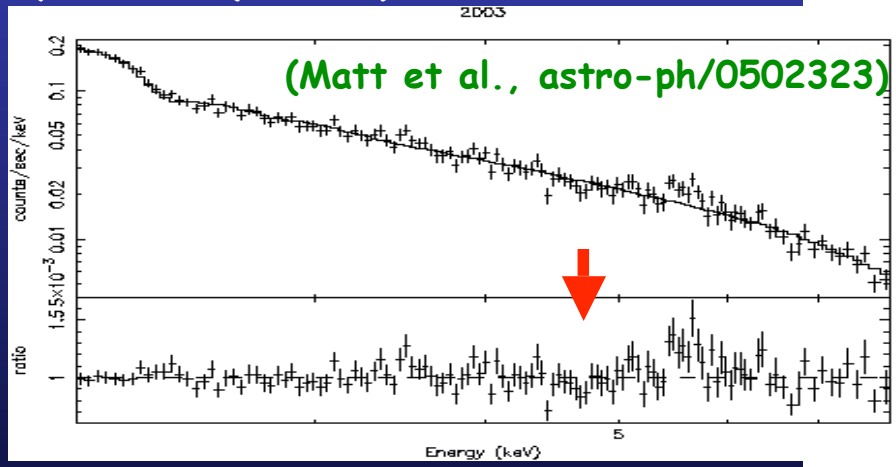


MCG-6-30-15 in low state
(Ponti, private com.)



E1821+643 (z=0.3) HETG data
(Yaqoob & Serlemitsos, 2005)

Q0056-363 (z=0.162) XMM data



(Matt et al., astro-ph/0502323)

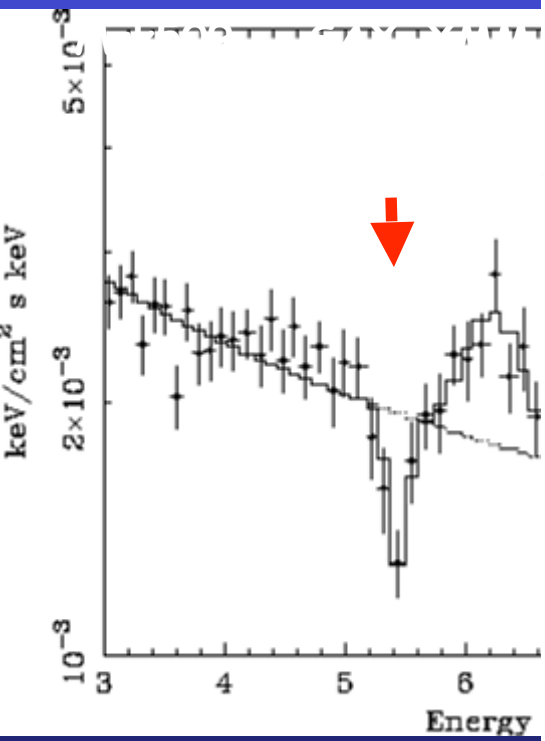
i) Fake lines?
ii) (very) wrong continuum (WA)?
iii) 2 different lines? ⇒ 1 narrow + 1 Kerr
(red, reverberation, tail of a Kerr line ?)
iv) 1 relativistic line with resonant absorption?

⇒ Probe relativistic bulk inflows!
(v~0.1-0.2c)

Accretion/inflows: FeK resonant *absorption* lines (iv/v)

Absorp

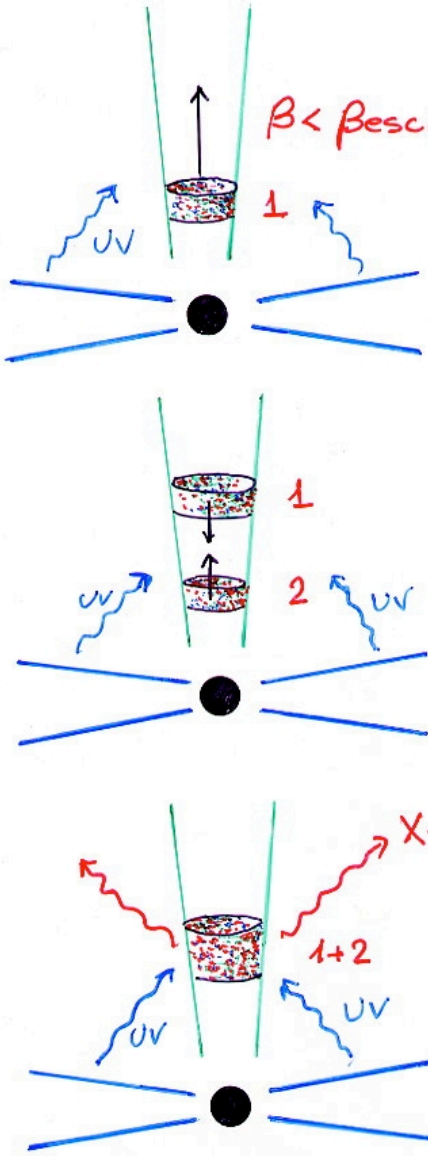
Mrk509 (z=0.03) SAX+



Mildly relativistic (v~0.2c)

"Aborted" jet ?

GG, Haardt, Matt, 2003



Relative Kinetic energy ⇒ heating

UV radiation field ⇒ cooling

⇓

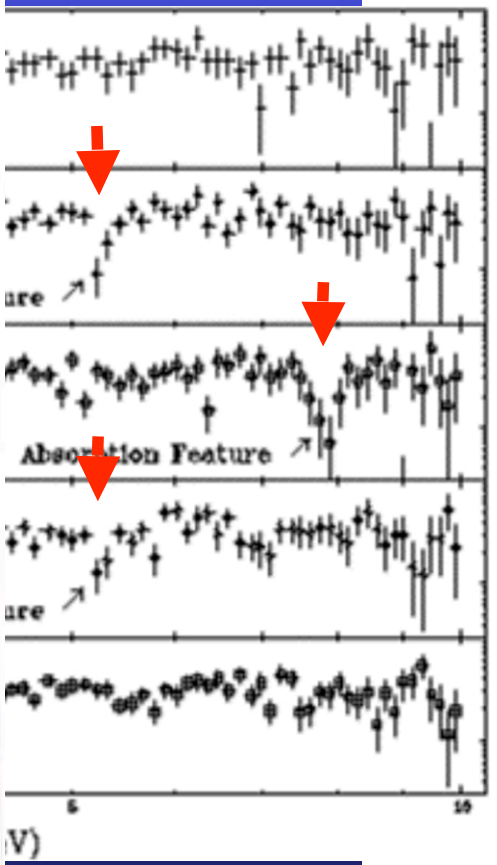
Thermal plasma (T_e ~ 50-100 keV)

Comptonization

if $L_{jet} \sim L_{DISK}$

⇒ τ = 0.1-1

f <20 ks



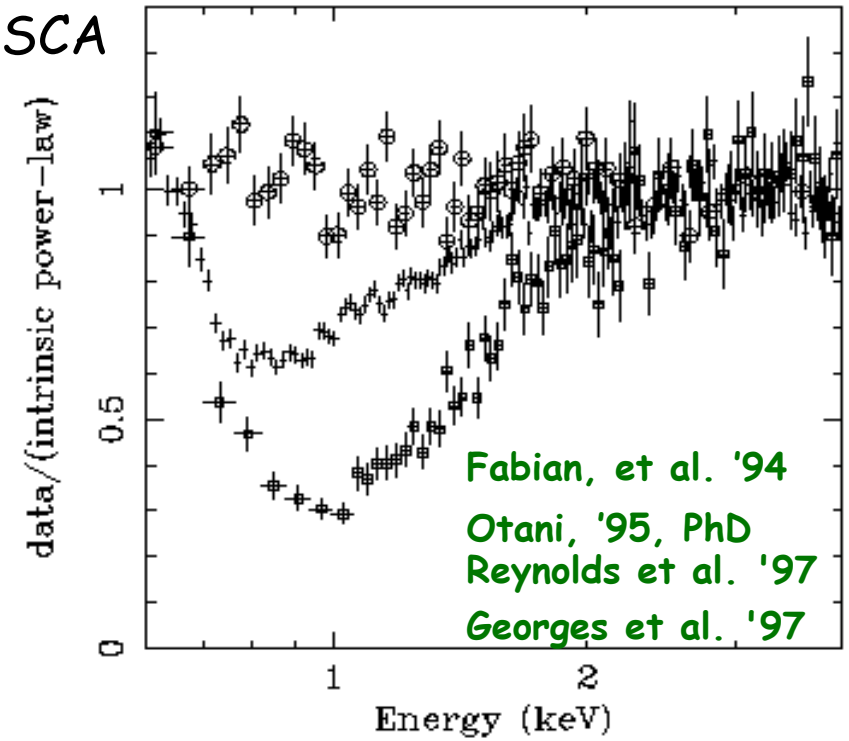
A&A, submitted

Ejection/outflows: Warm absorbers (i/iii)

Many great details from Chandra/XMM gra

50% of all Sey 1s exhibit Warm Absorbers

ASCA

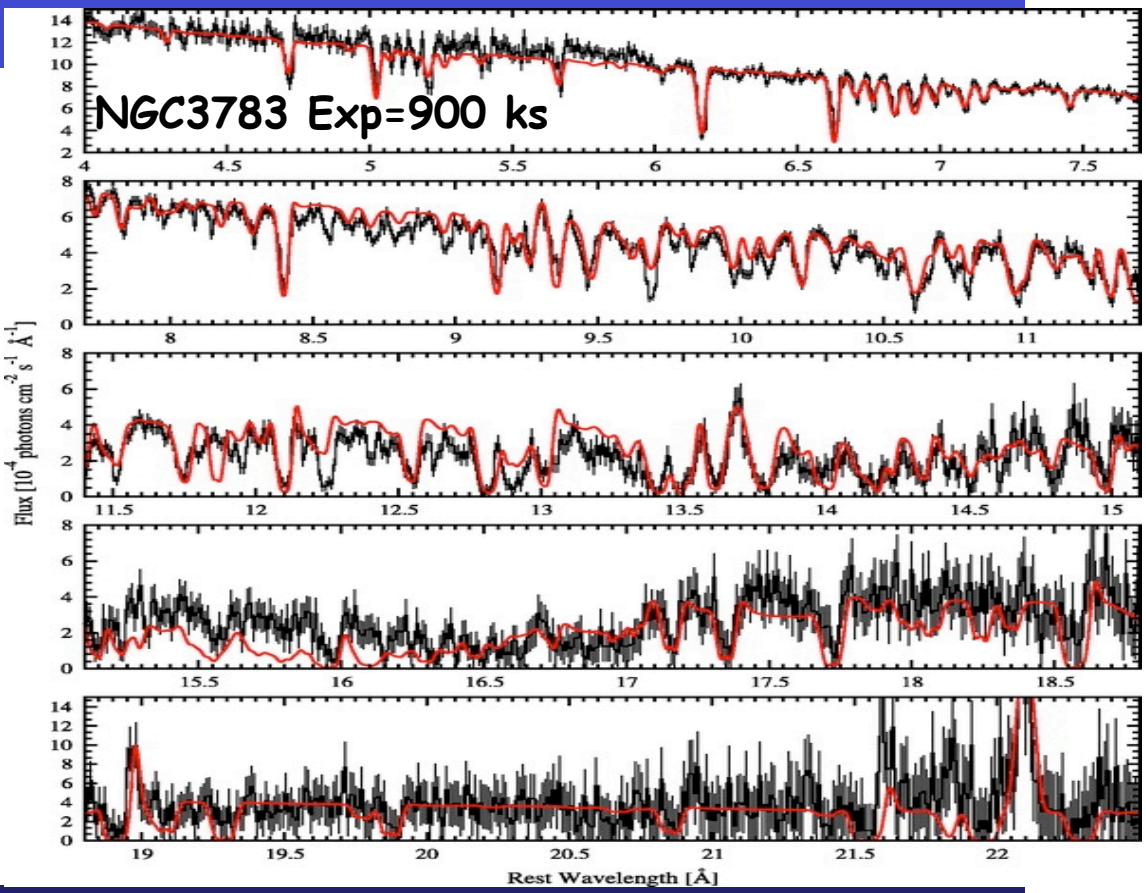


Fabian, et al. '94

Otani, '95, PhD

Reynolds et al. '97

Georges et al. '97



Kaspi et al. '01; Netzer et al. '02;
Georges et al. '03; Krongold et al. '03

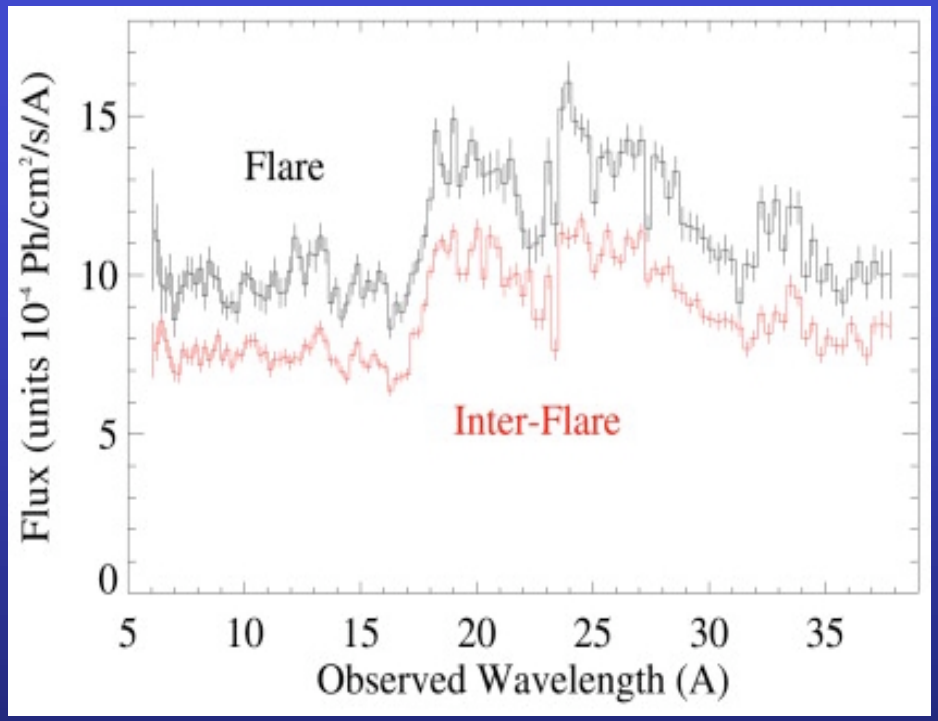
⇒ Clear that warm absorbers located between BLR and NLR, and dynamically important

⇒ Mostly multiple ionization & kinetic components: outflows with v~100-1000 km/s

Ejection/outflows: Warm absorbers (ii/iii)

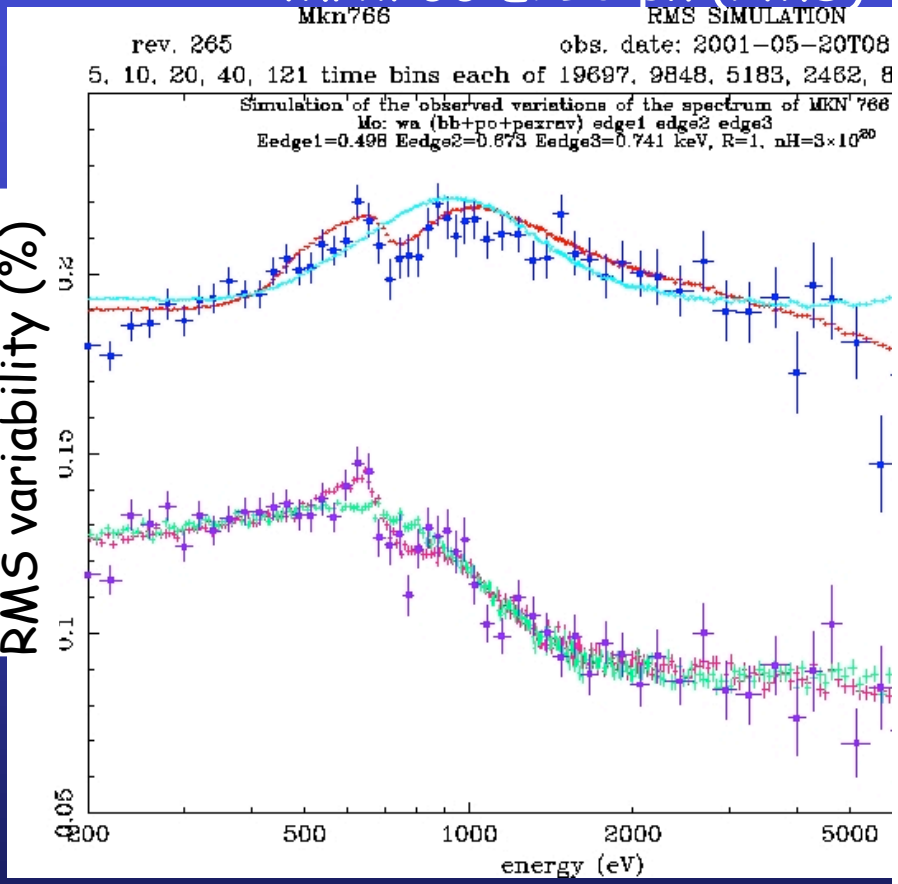
WA variability on timescales 1000-10000s

Mrk766 RGS



Mason et al. 2003

Mrk766 EPIC pn (RMS)

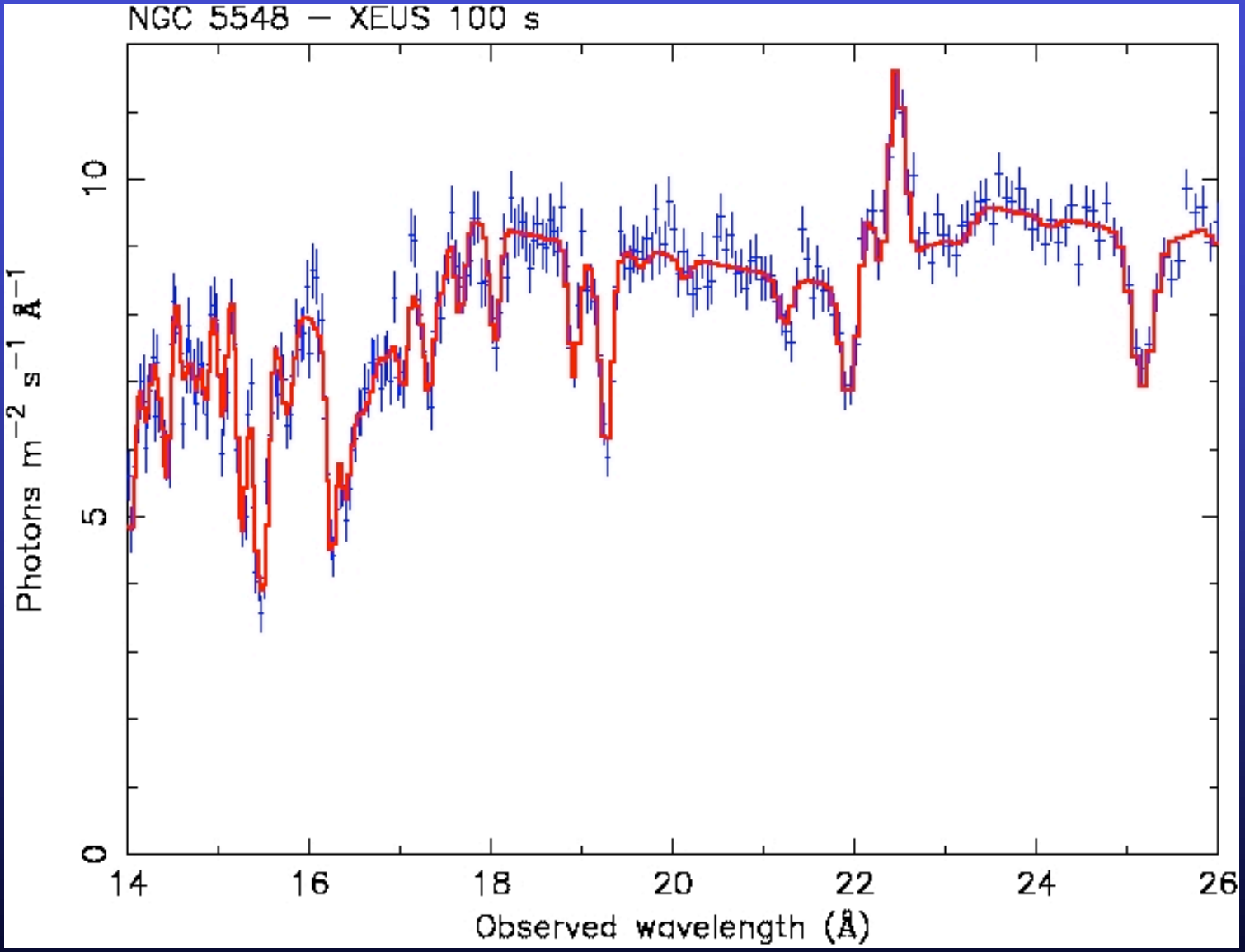


Ponti et al., in prep.

Different phases in WA should respond differently:
e.g. with a range of response times in a radially segregated flow
Disentangling WA vs. soft disklines, as well as constraining
location and covering factor will require variability studies!!

Ejection/outflows: Warm absorbers (iii/iii)

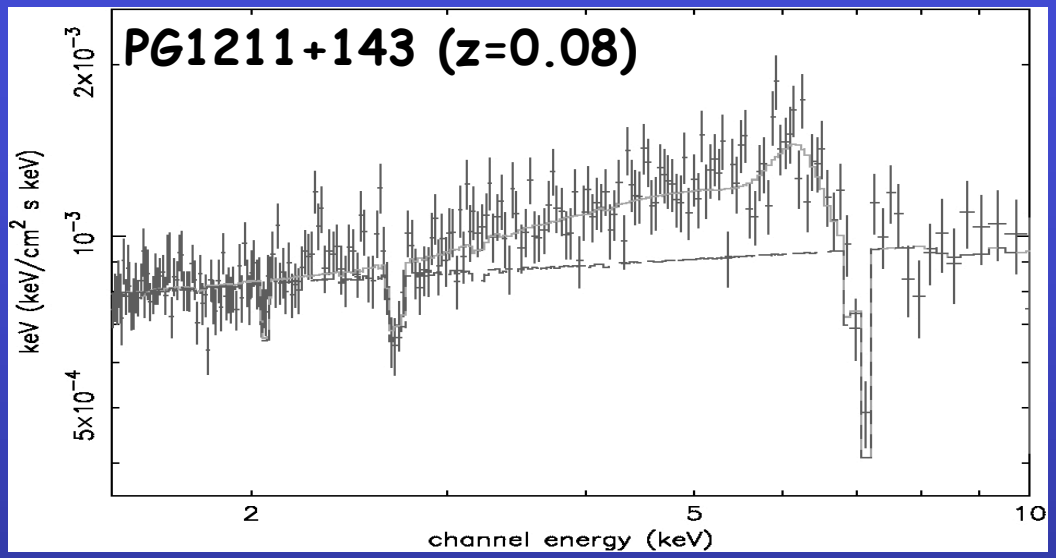
Best would be a combination of highest effective area (for variability stu
and highest energy resolution (to remove ambiguities due to line blending)



(thanks to Jelle Kaastra)

Ejection/outflows: Massive outflows (i/iii)

Pounds et al. 2003

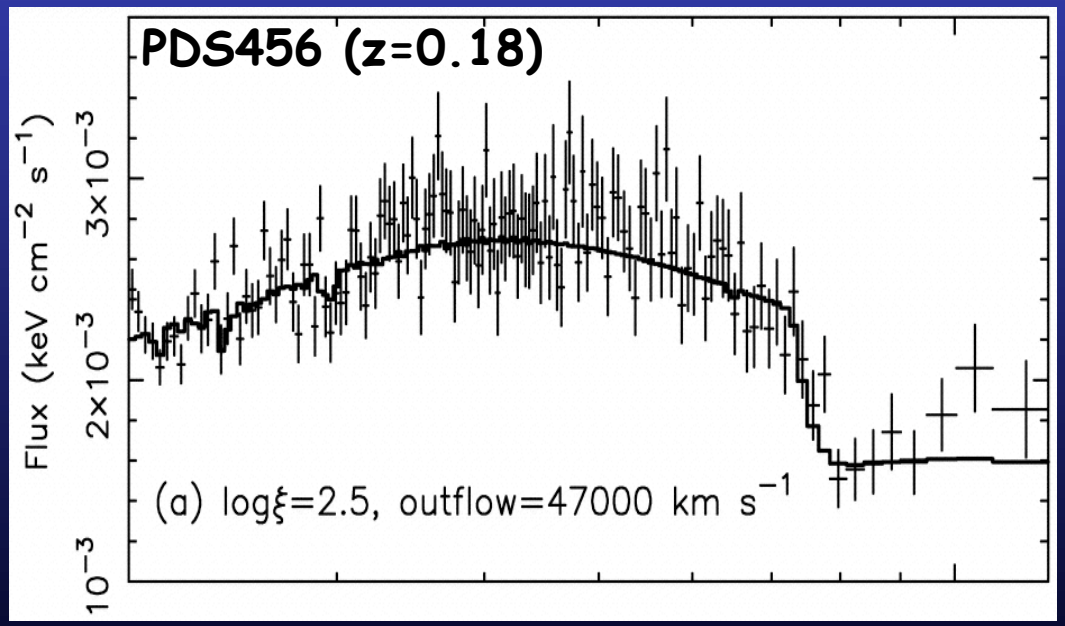


⇒ massive, high velocity and highly ionized outflows in several RQ AGNs/QSOs

mass: comparable to Eddington

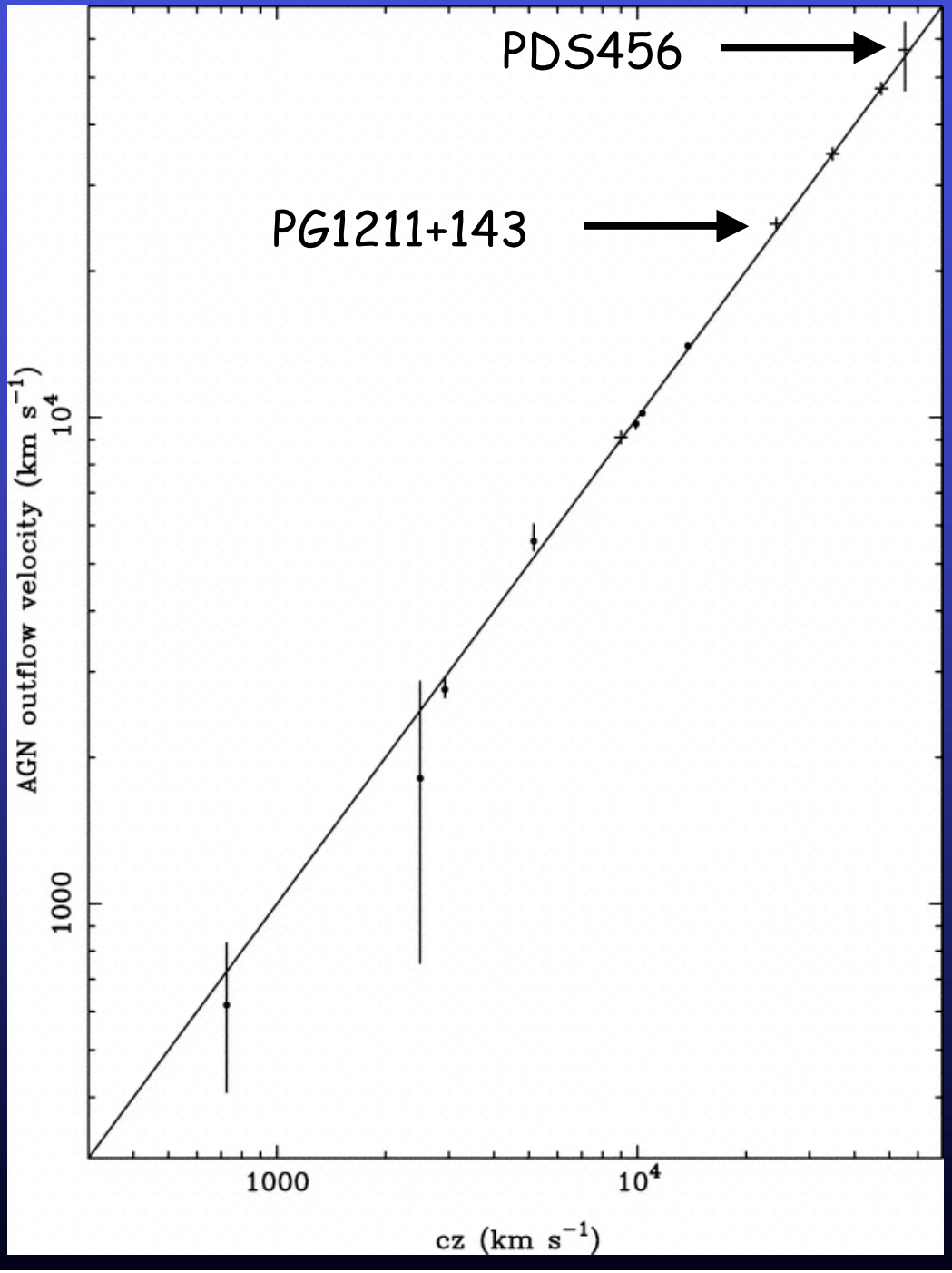
accretion rate (~M$_\odot$/yr)

velocity: at least ~0.1-0.2 c



Reeves et al. 2003

Ejection/outflows: Massive outflows (ii/iii)



McKernan, Yaqoob & Reynolds 2004

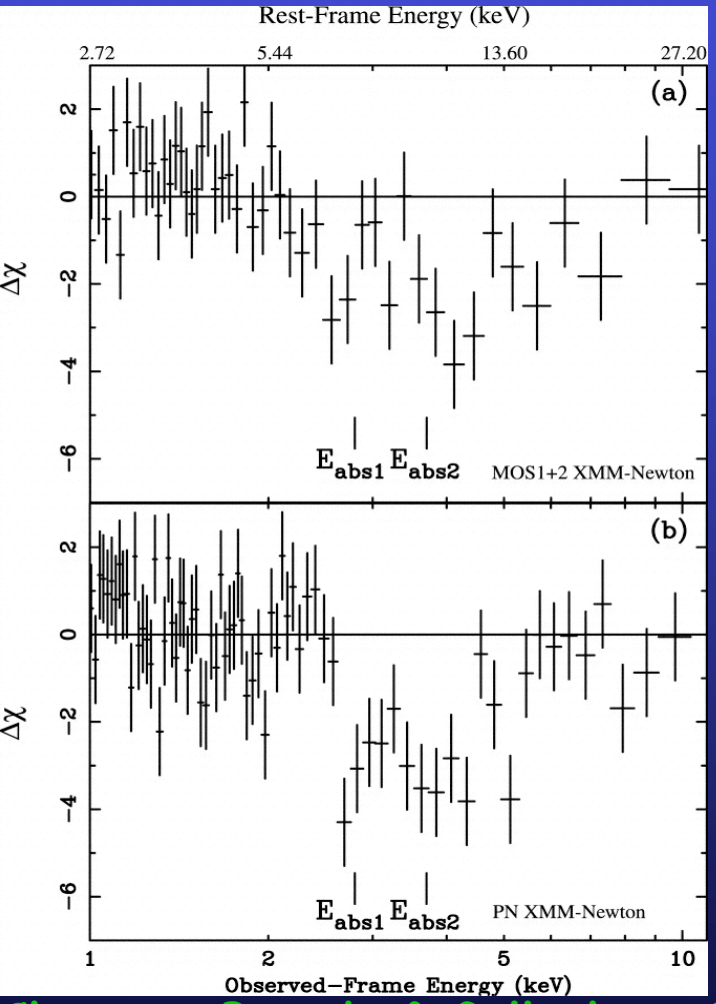
Cast doubts on the AGN origin of high-velocity absorption gas...because consistent with local WHIGM (N.B.: PDS456 is along Gal. Plane)

Ejection/outflows: Massive outflows (iii/iii)

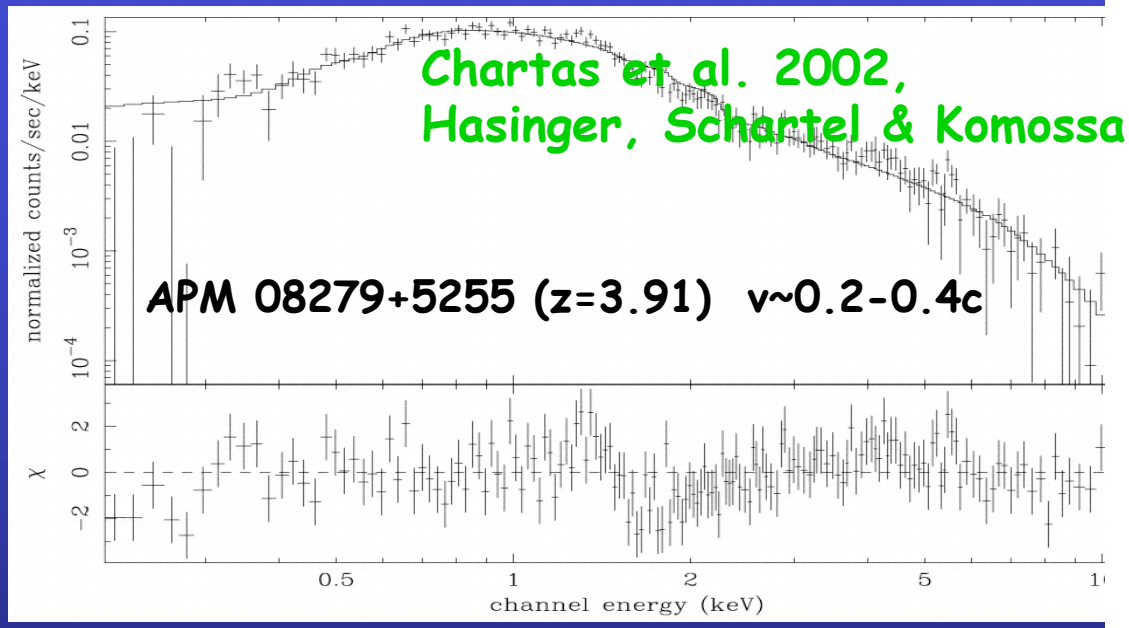
3 other cases certainly do not fit in the McKernan et al. relation

2 high-z BAL QSOs

PG 1115+080 (z=1.72) v~0.1-0.3c

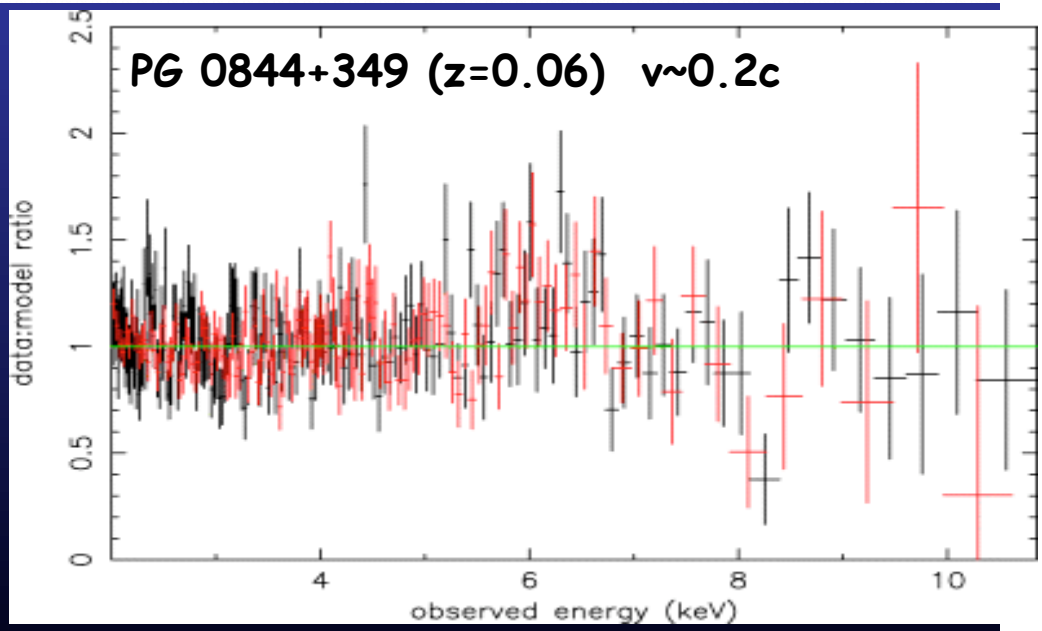


Chartas, Brandt & Gallagher, 2003



Chartas et al. 2002,
Hasinger, Schartel & Komossa 2002

APM 08279+5255 (z=3.91) v~0.2-0.4c

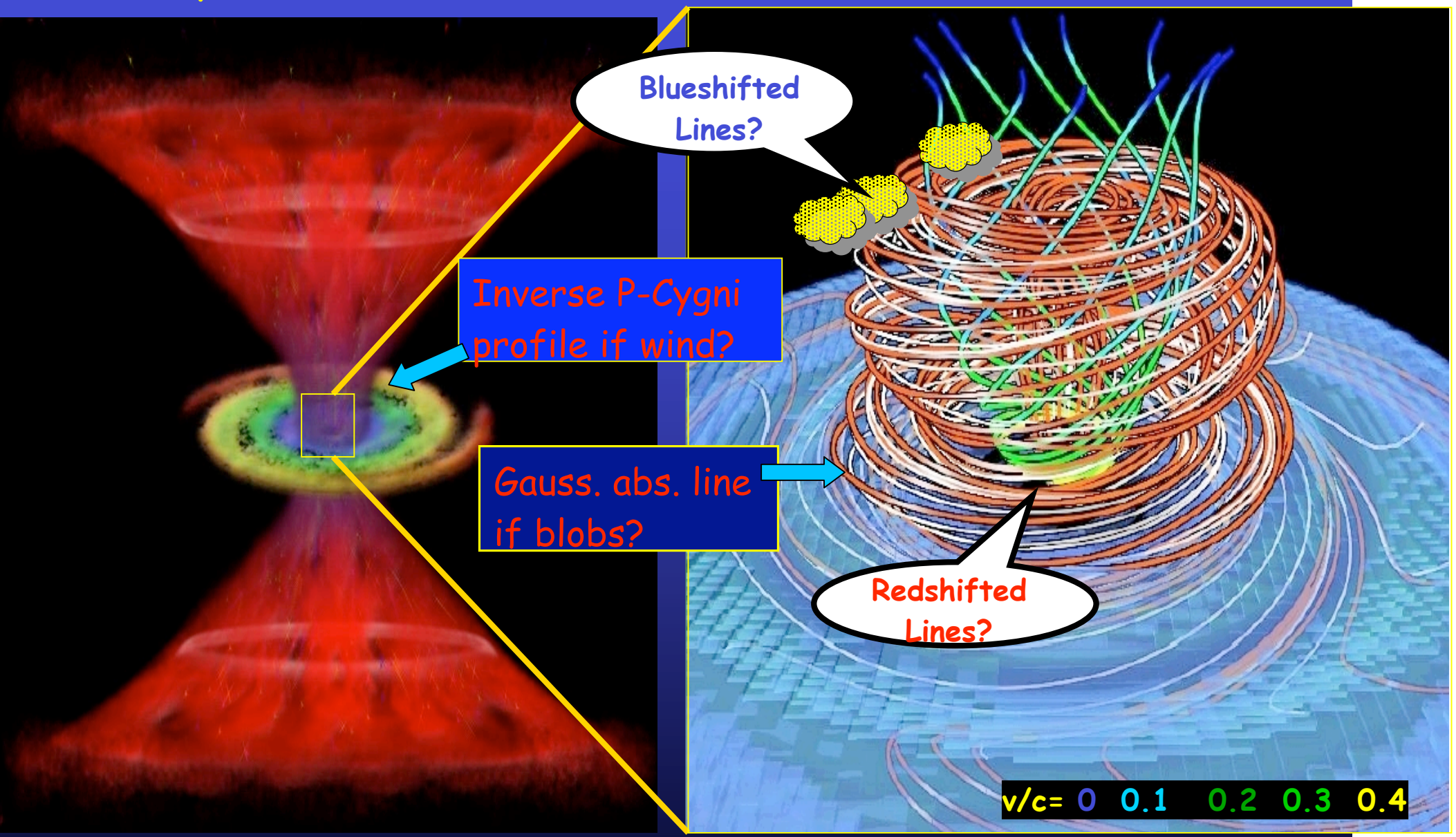


Pounds et al. 2003

N.B.: Would have been undetected at z=0...

Not only outer structure...

But also inner structure?



Quasar wind model by Elvis 2000

Magnetic Tower by Kato et al. 2003

(see also Lynden-Bell 2003)

In my opinion…

Transient redshifted absorption lines (rel. inflows) and transi
blueshifted absorption lines (rel. outflows) are naturally expect
models involving blobby/winds ejections and downfalling of mat
(e.g. aborted-jet by Ghisellini et al., 2004)

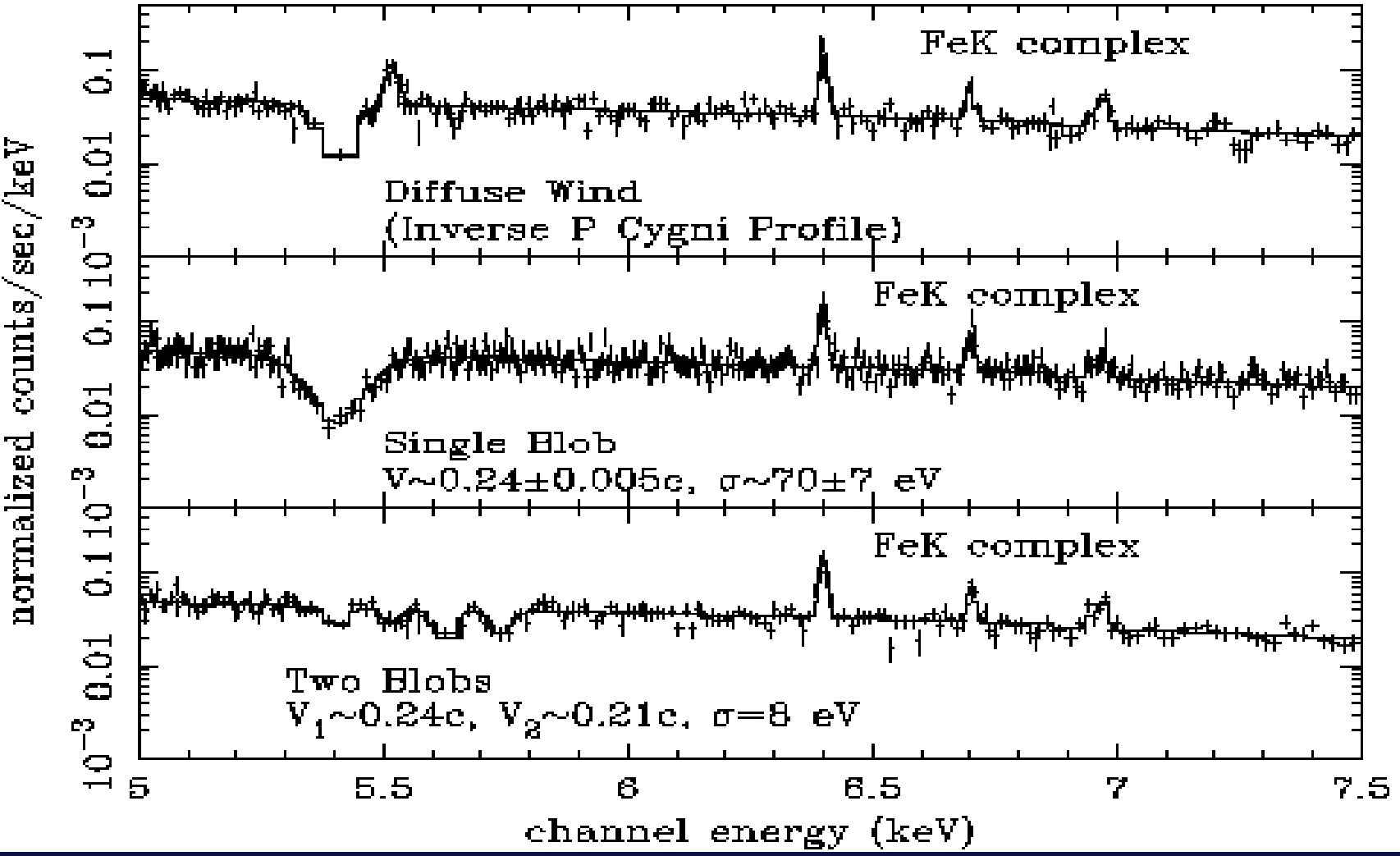
N.B:

- Plausible to have a transition to relativistic jets
- Seyferts do have (failed?) jets
- "Physical bias" against highest ionization in/outflowing gas, (detectable only with Fe)
- "Detection bias" against transient redshifted features
- "Observational bias" against highest-v blueshifted features (poor high-energy sensitivity…cut-off at ~7 keV)

→ "The tip of the Iceberg?"

Simulations: (i/v) ASTRO-E2

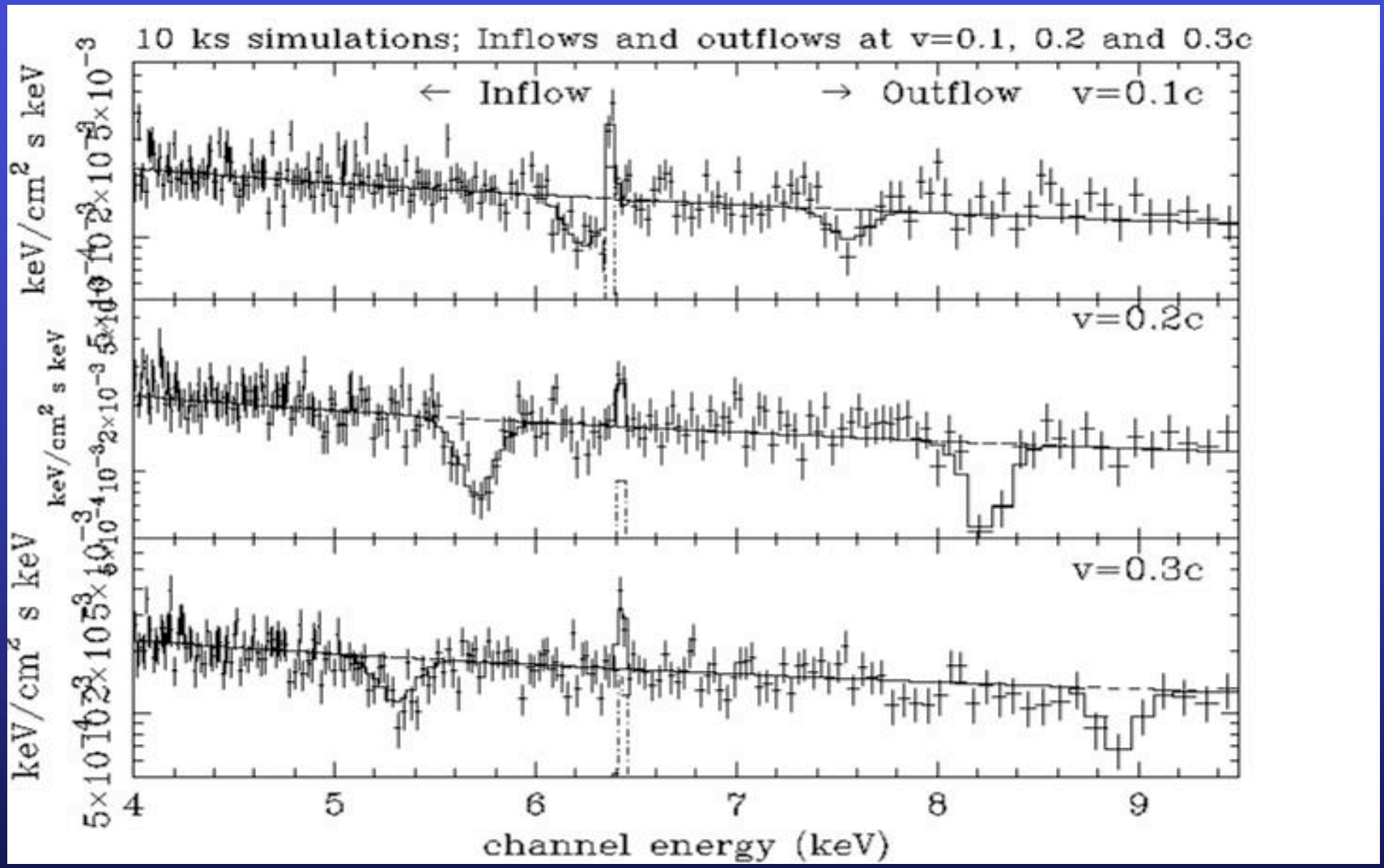
Mrk 509, Astro-E2 simulation 100 ks



High energy resolution to distinguish beetwen wind and blob(s) (line profile)

Simulations: (ii/v) XMM-Newton long

Mrk 509: XMM-Newton simulation (F_x=2x10^{-11} cgs)



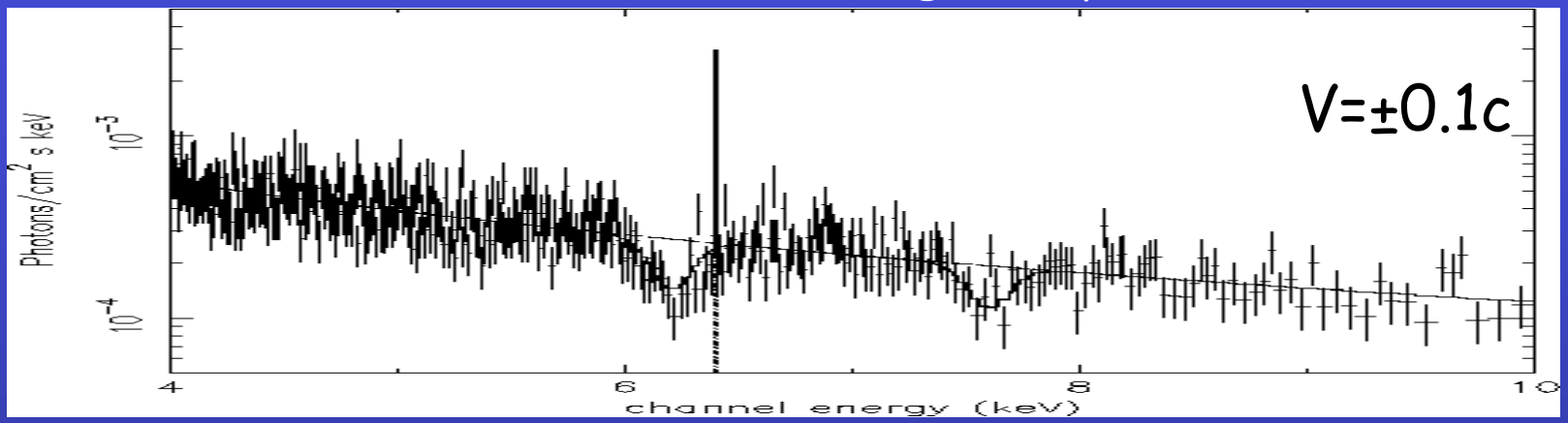
Highest throughput for time-resolved detections of abs. lines

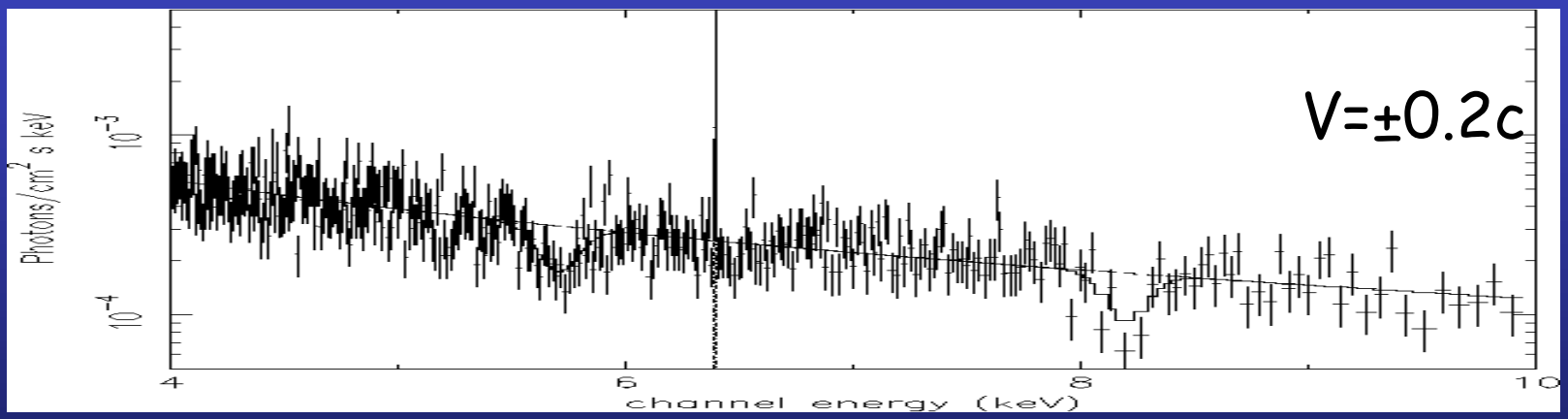
⇒ real-time, extreme dynamics, i.e. inward and outward accelerations!?

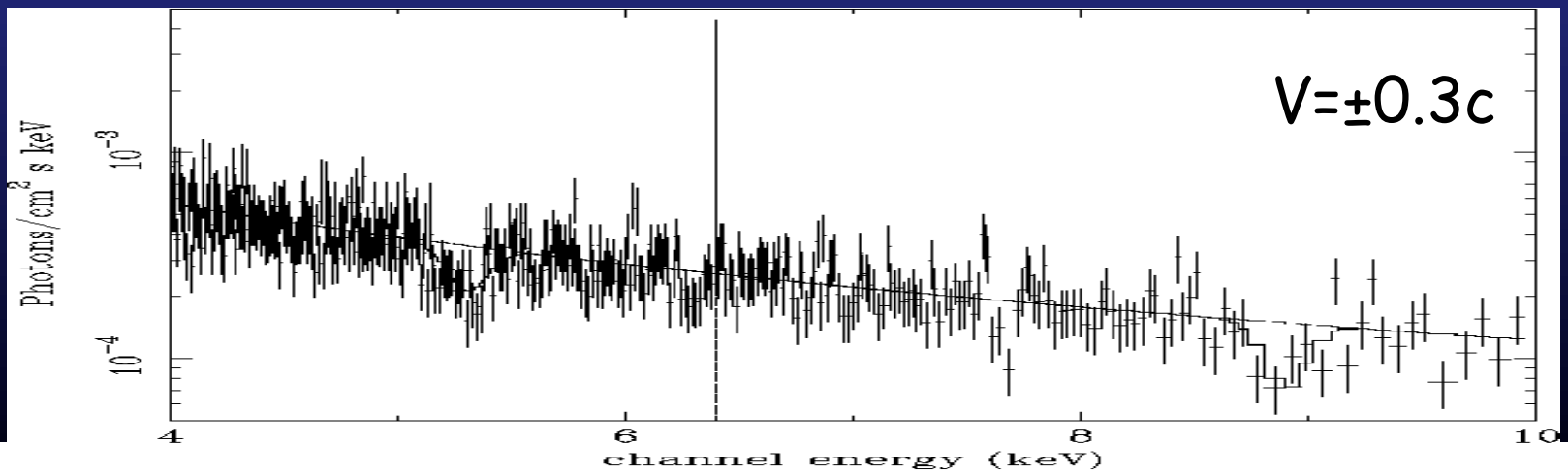
(line Δv/Δt) ....blob=test particle to test Kerr vs. Schwarzschild GR

Simulations: (iv/v) XEUS

Mrk509: XEUS TES F(2-10)=10^{-11}cgs Exposure=100s S/N>3

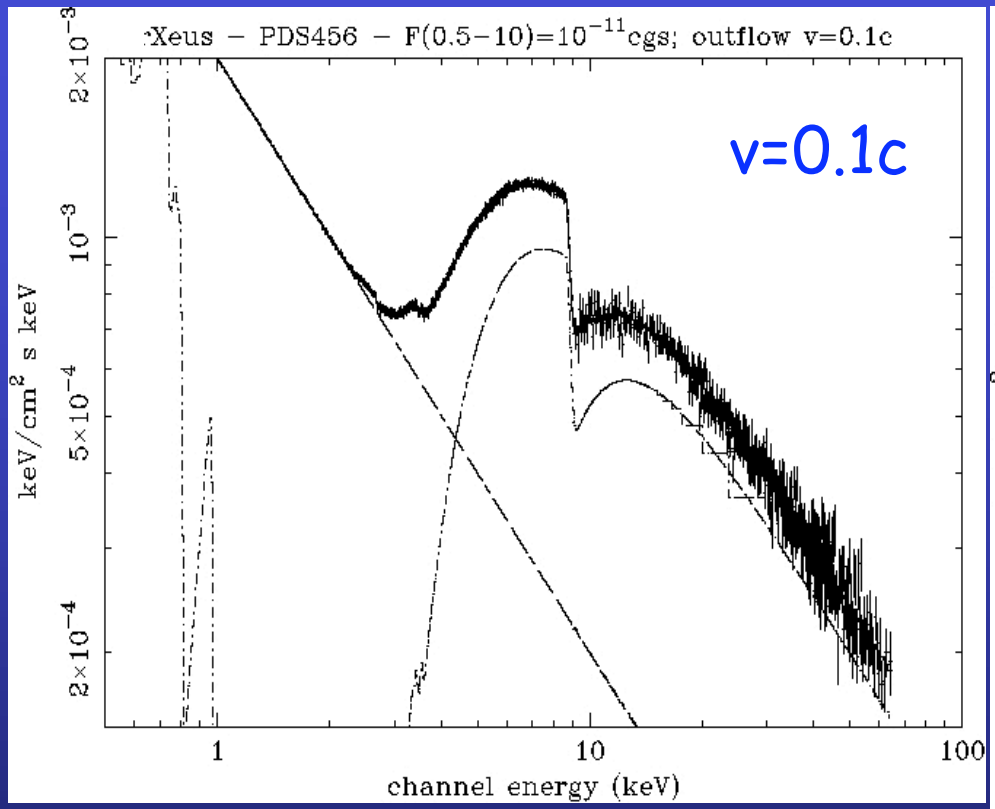




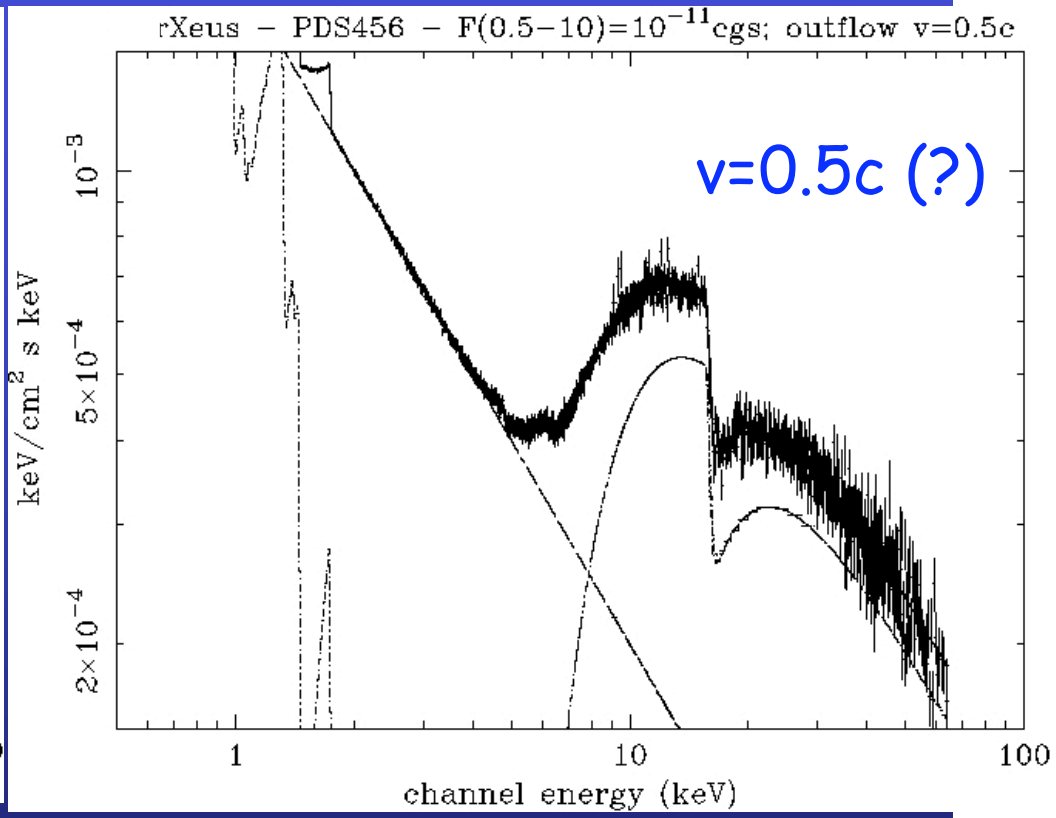


Simulations: (iv/v) XEUS

PDS456: XEUS WFI + CdTe (100 ks exposure)



(Wfi: S/N=100; Cdte: S/N=10)



(Wfi: S/N=50; Cdte: S/N=10)

Edges at E~7.1-9.0 keV (rest-frame) + v_{out}~ 0.1-0.5c

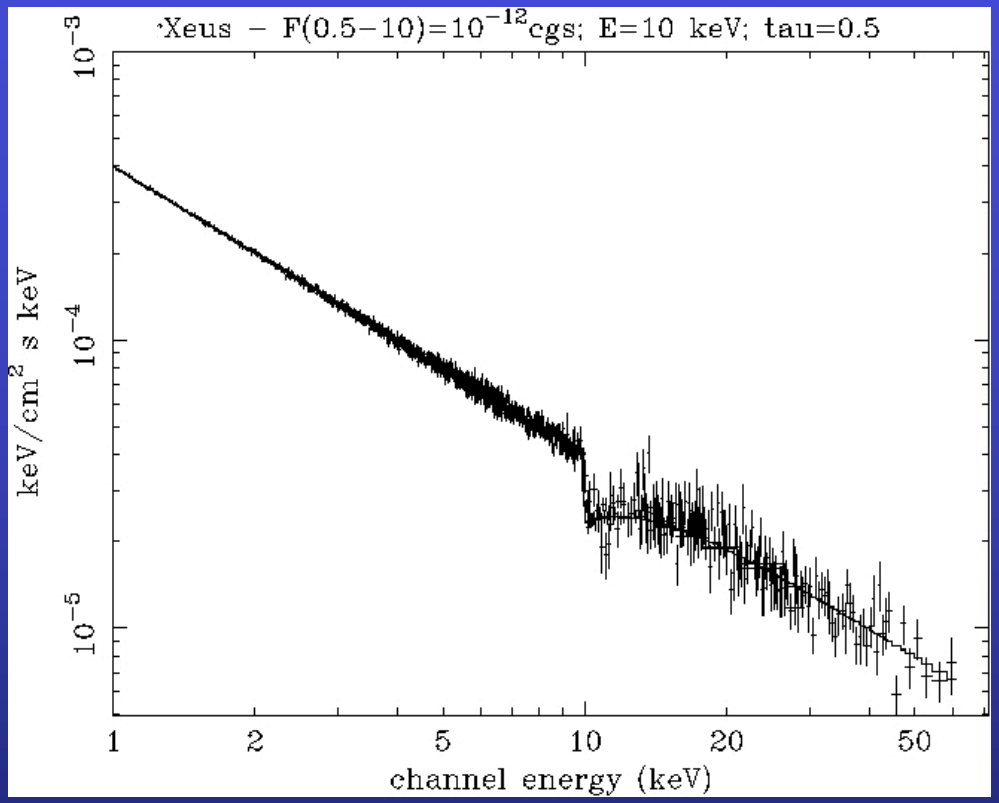
$\Rightarrow E_{observed}$~ 8-14 keV !!

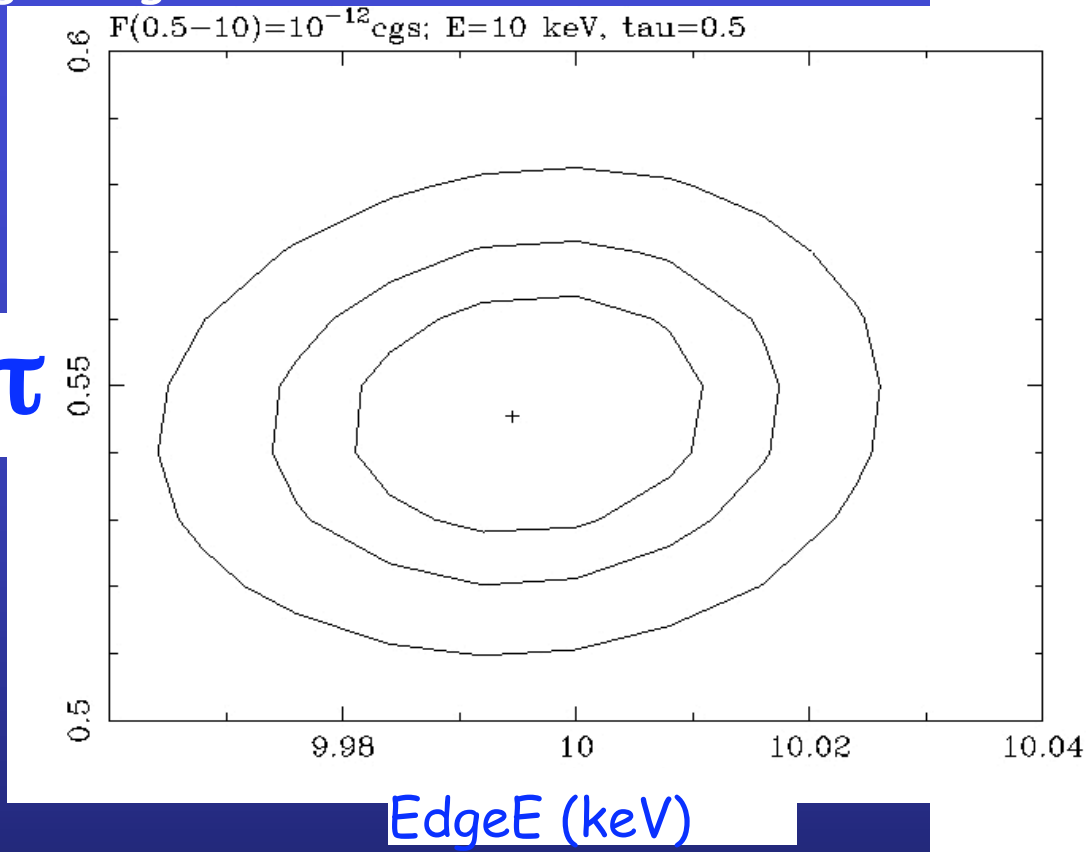
(maybe the reason why never seen earlier, except for high-z sources)

➡ High energies is a MUST HAVE to study relativistic outflows!!

Simulations: (v/v) XEUS

Power-law + single edge @ 10 keV





F(2-10)=10^{-11} cgs ⇒ τ within few %, _(E)<<Eres.

F(2-10)=10^{-12} cgs ⇒ τ within 5-10%, _(E)<Eres.

F(2-10)=10^{-13} cgs ⇒ τ within 20-30%, _(E)~Eres.

⇒ Possible to constrain Nh, _, and v of outflow

and their variations on timescales of 1000-10000 s

Goal is to probe the flow dynamics (Δv) of innermost regions by means of detection and time-resolved spectroscopy of red- and blue- shifted *absorption* lines

Fiducial numbers:

We wish to follow abs. lines from, say, ~1 to ~10 Rs, with intervals of 1Rs

Let assume v~0.2c, then for

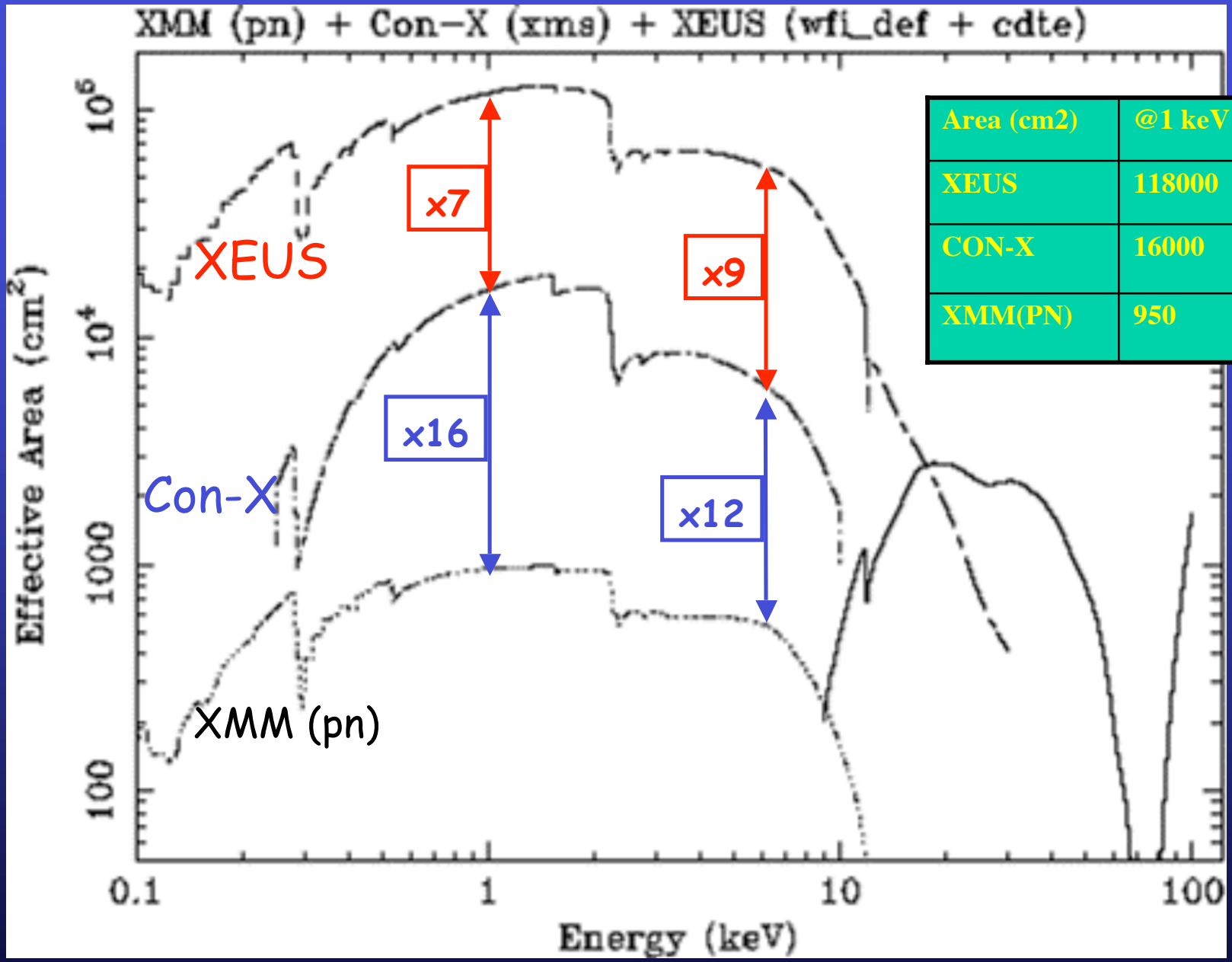
BH mass= 10^8 $M_\odot$ ΔTime-scale ~ 5000 s

BH mass= 10^6 $M_\odot$ Time-scale ~ 50 s

Scaling from Mrk509 and XMM, and assuming EW(Fe)=-100 eV ⇒

	Con-X(6000cm^2)	XEUS(60000cm^2)@ 6ke
F(2-10)=2x10^{-11}cgs (~ 15 sources)	1000s	100s
F(2-10)=2x10^{-12}cgs (~ 50 sources)	10000s	1000s
F(2-10)=2x10^{-13}cgs (~ 250 sources)	100000s	10000s

Redo needed because mostly BH mass< 10^7 $M_\odot$

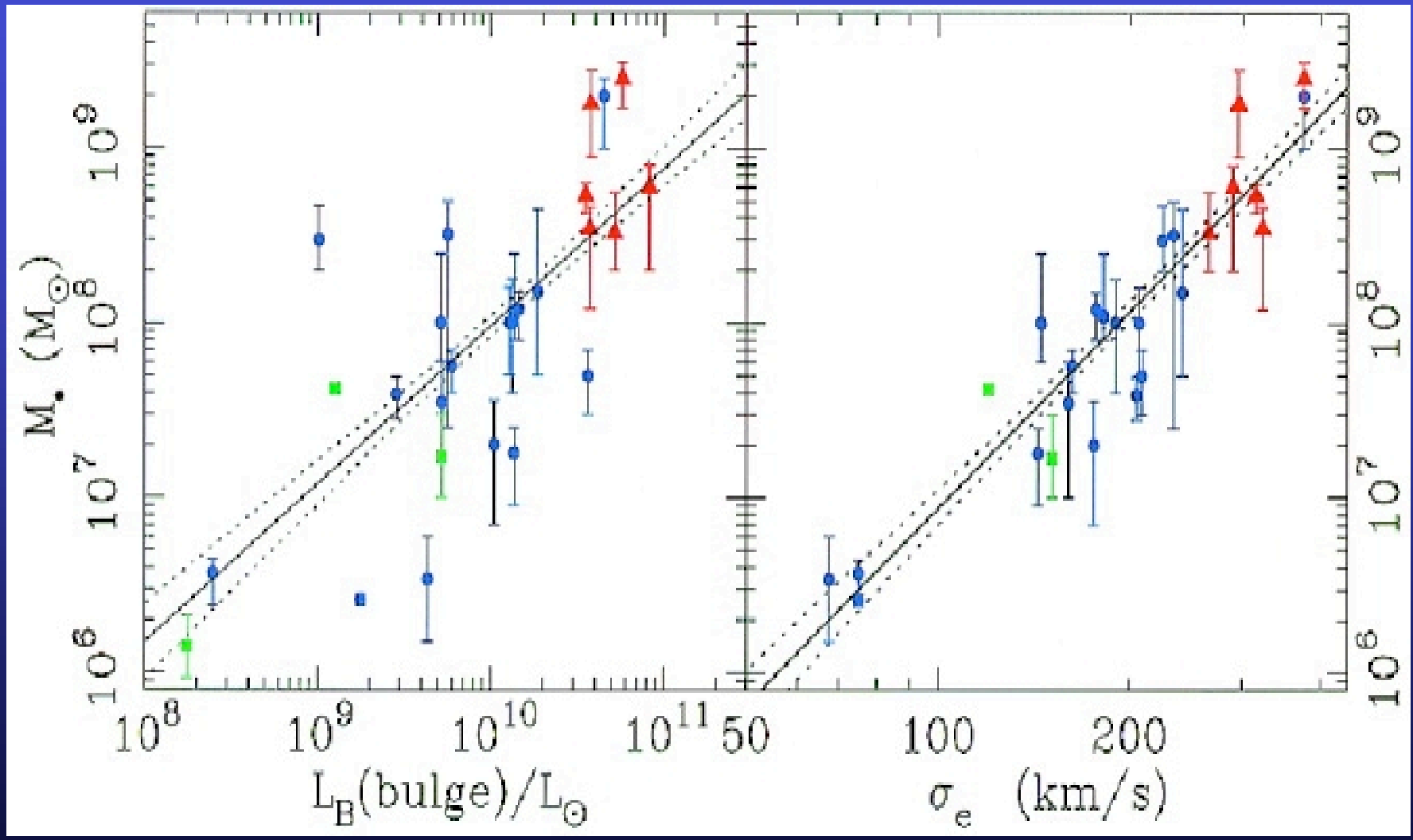


Area (cm2)	@1 keV	@6 keV
XEUS	118000	56000
CON-X	16000	6200
XMM(PN)	950	530

Effective areas such as these will open up the area of X-ray "BAL" spectroscopy

Cosmology: BH-Gal. relation

Important not only for physics of jets/ejection, but also for feedback mechanism between SMBH and host galaxy



Magorrian et al. '98

Tremaine '02; Gebhardt '02...etc

(see e.g. King and Pounds '03, Crenshaw, Kraemer & George '03, ARA&A)

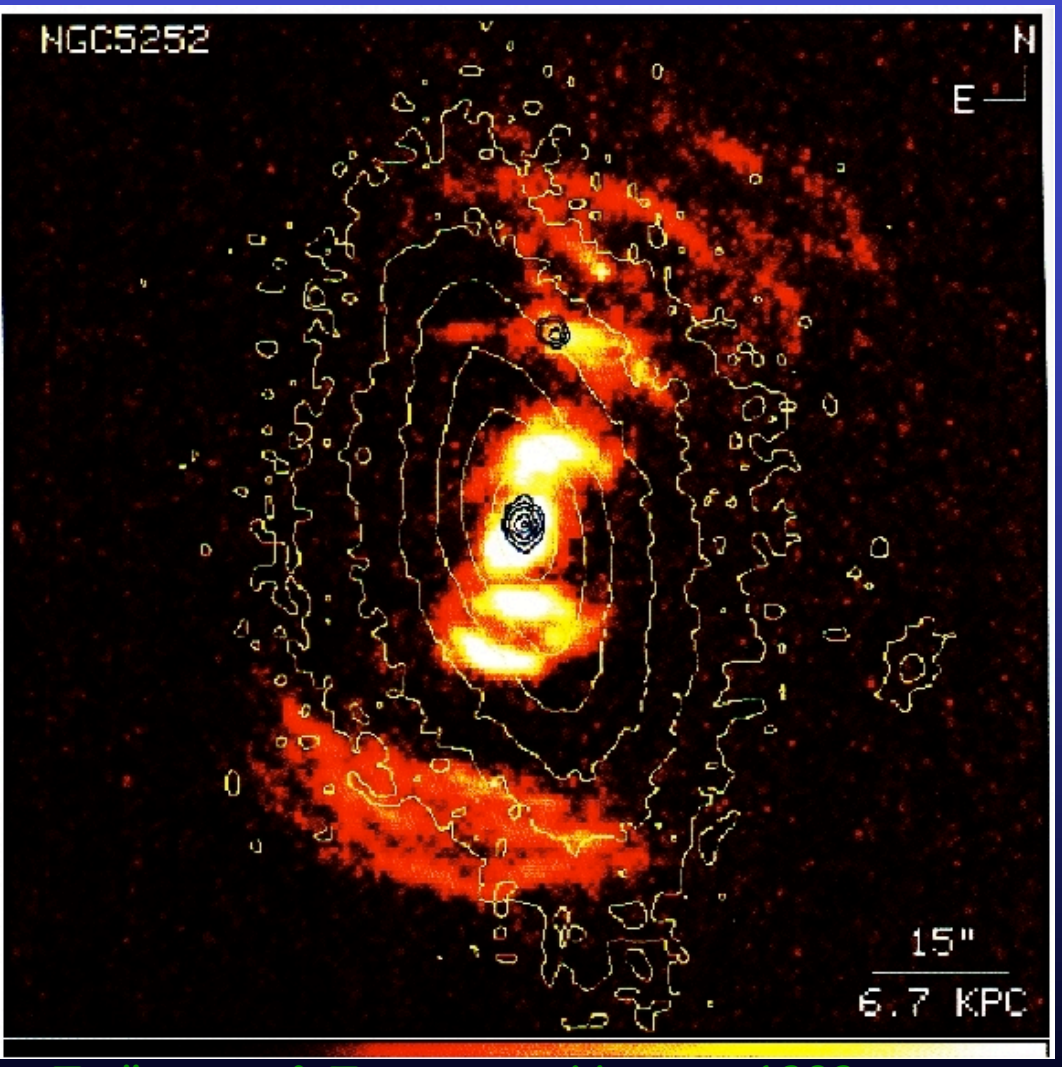
$M_{bh} \sim$ _ ^{4}

Cosmology: BH-Gal. relation

∃ link maybe not so surprising

Seyfert 2 galaxy NGC5252

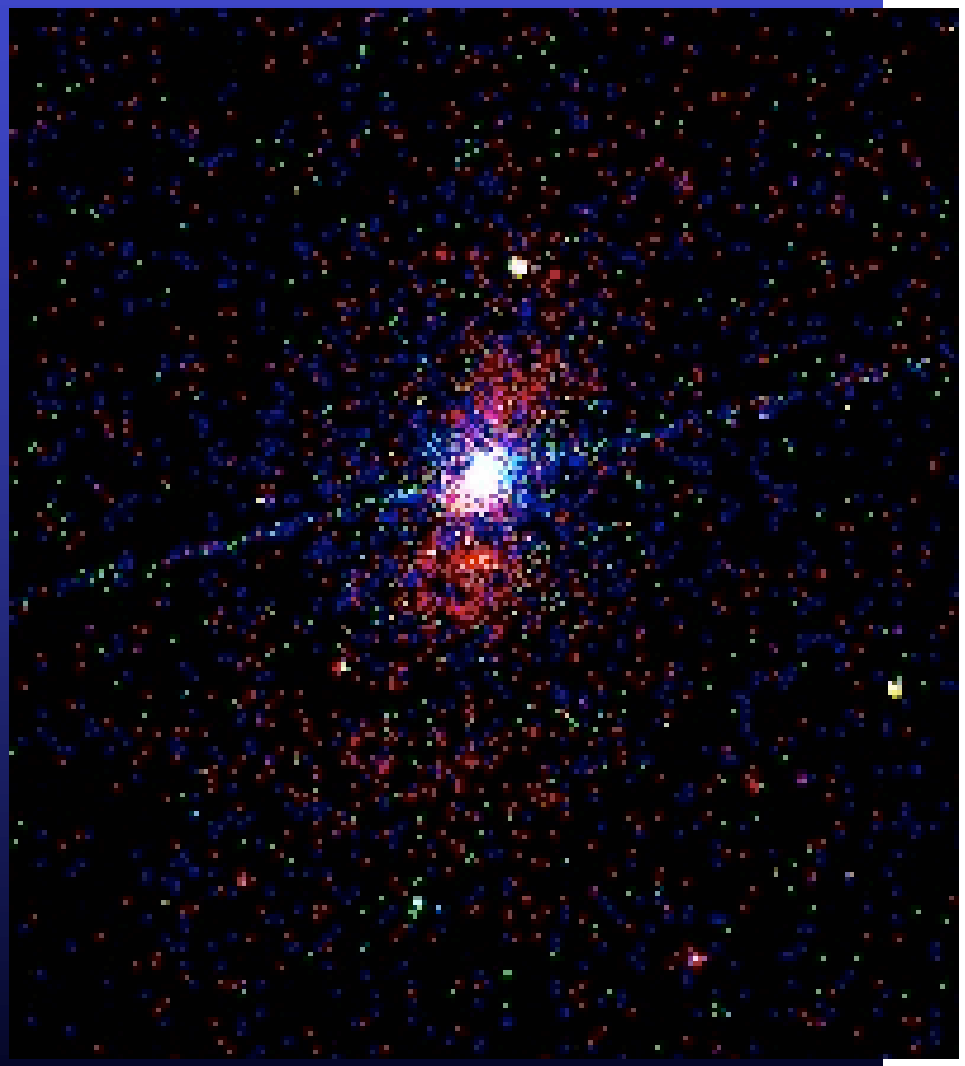
OIII ionization cones



Tadhunter & Tsvetanov, Nature, 1989

Wilson & Tsvetanov, 1994

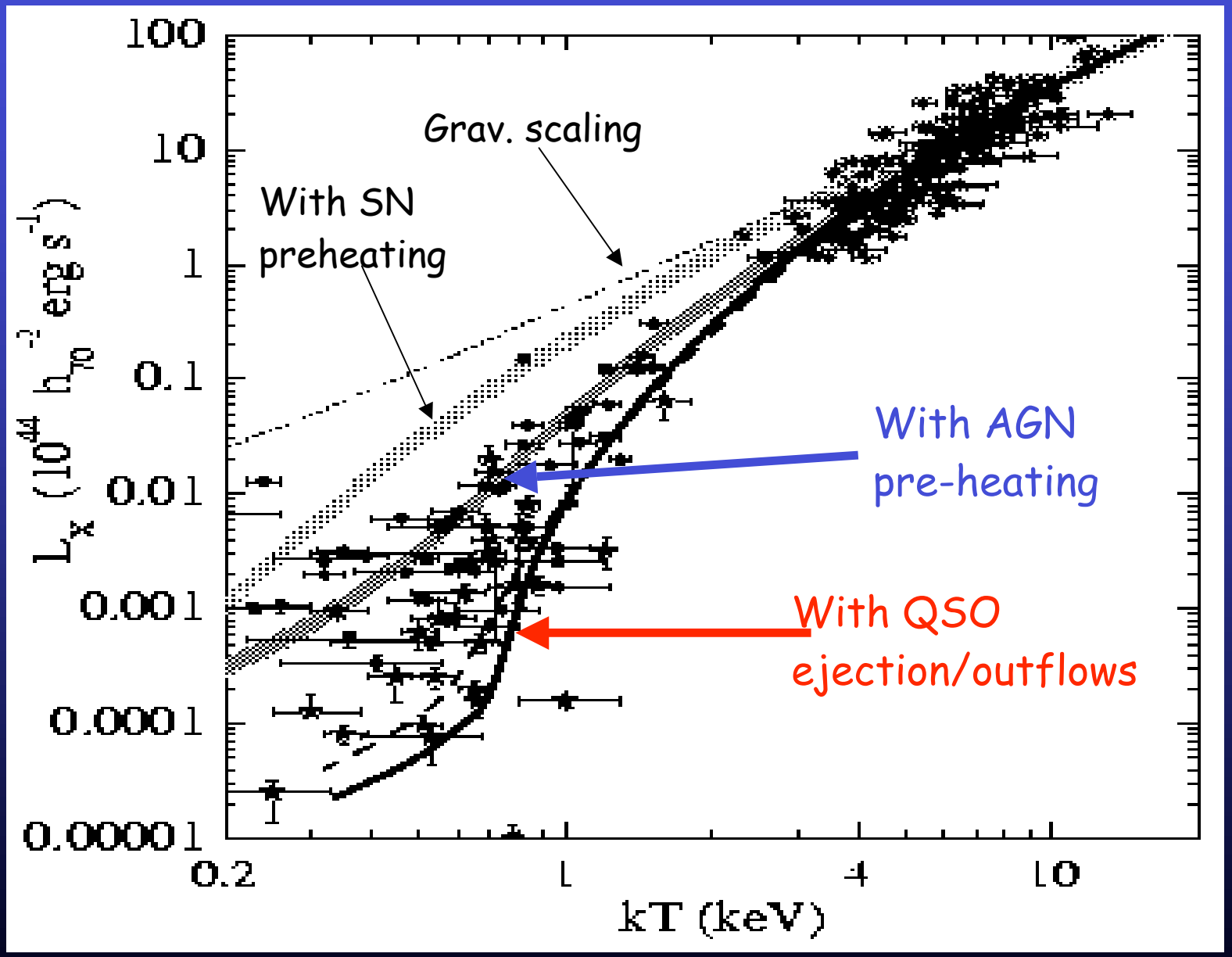
X-ray ionization cones



Camilla Boschieri, laurea thesis

Cosmology: BH(AGN) – groups and clusters relation

Energy feedback from AGN or quasars needed to recover preheating in clusters, i.e. L-T relation?



Lapi, Cavaliere & Menci, 2005, astro-ph/0410028

Cosmology: BH-Gal. relation

Finally, interesting ∃ also for analogy with blueshifted Fe features from outflows in SNae, XRBs, micro-quasars and GRBs !?

To be done for next meeting?...

Summary

Besides Fe X-ray emission lines, there is now evidence for
Fe X-ray absorption lines in AGNs (both Sey and QSOs)

This topic still requires better measurements of intensity, energy and frequency/recurrency but has a great potential for the study of:

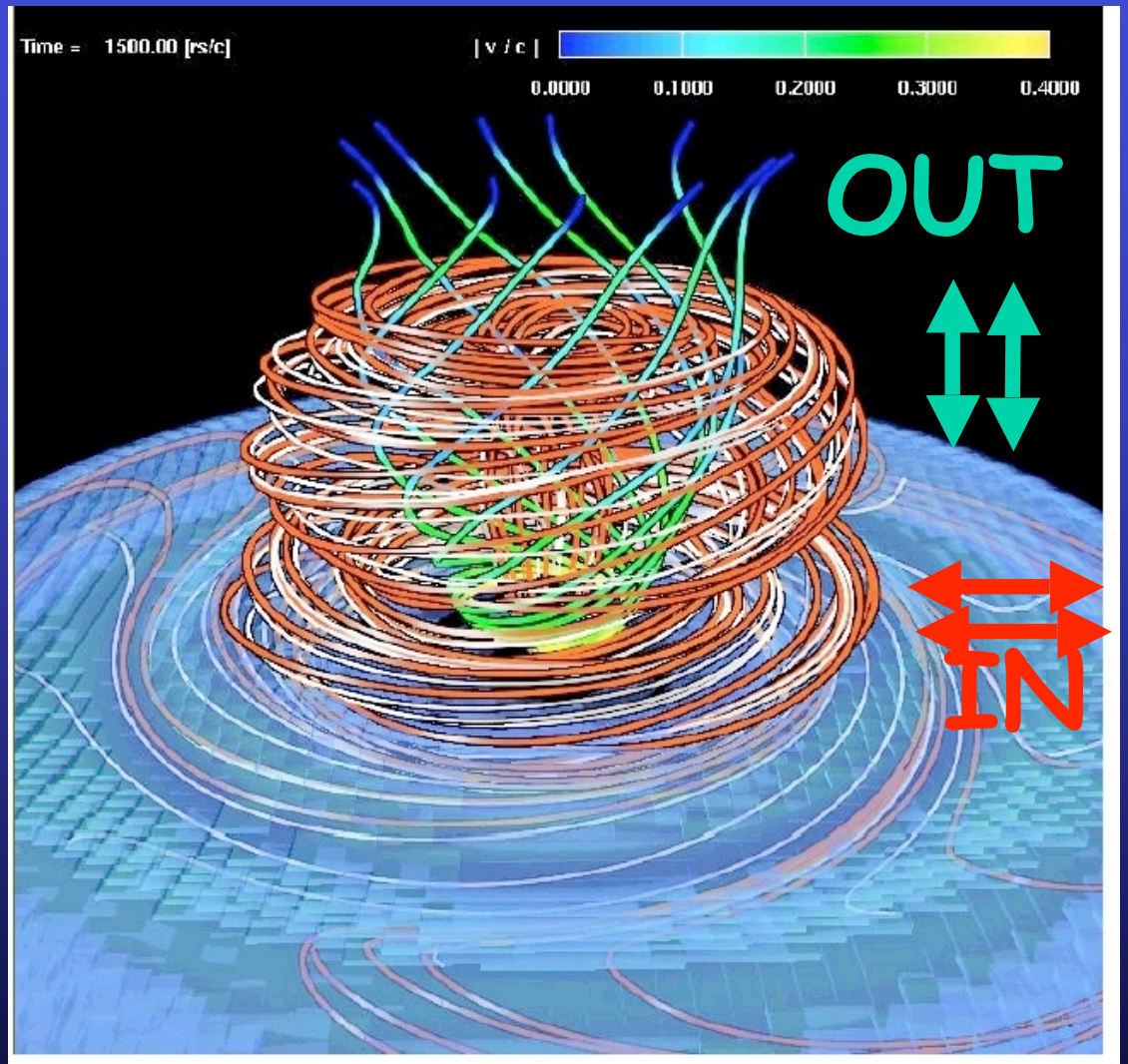
i) innermost regions of accretion flows (blobs=test particles!?)
ii) launching mechanisms/characteristics of outflows/jets
(mechanical energy emerging from BH)

Important not only for (relativistic) physics but also for link with cosmology

The driving observational requirement for this topic is to have
+ analogies with other sources
the highest possible throughput between ~1-50 keV
1-6 keV mandatory for redshifted abs. lines
6-50 keV mandatory for blueshifted abs. lines
(↑ energy resolution is a plus, but really needed
only for low-v (thus low _ and _) plasmas like WAs)

Thanks for your attention

from accretion/INflows to ejection/OUTflows



Magnetic Tower by Kato et al. 2003
(see also Lynden-Bell 2003)